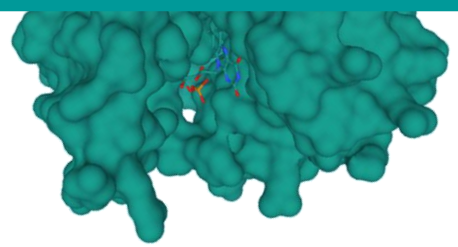
ETH zürich

Department of Chemistry and Applied Biosciences
Institute for Chemical and Bioengineering

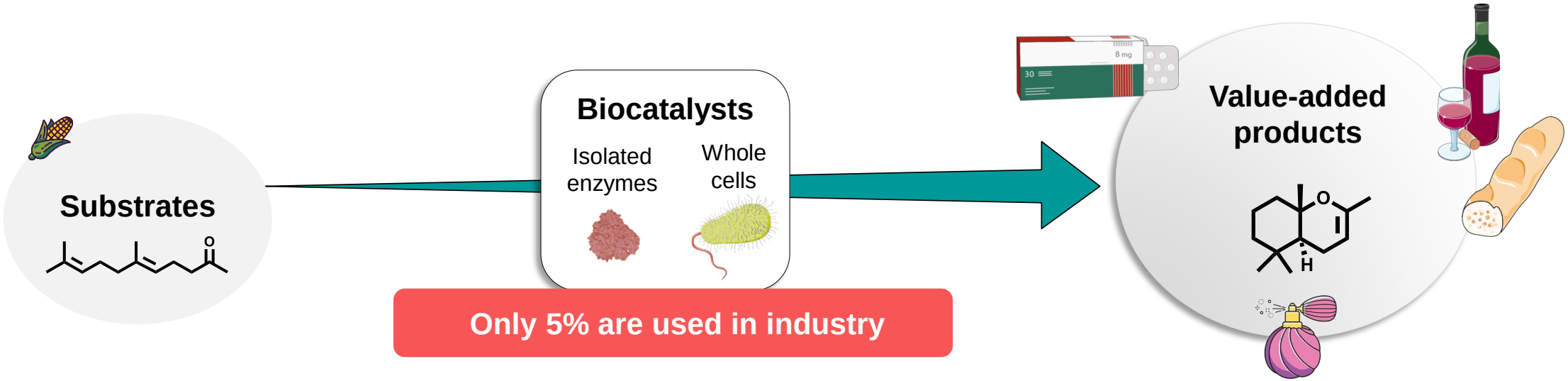
VSC Research Project Info event
11th December 2024

Protein Engineering & Enzyme Discovery for Sustainable Biocatalysis



Ana I. Benítez-Mateos
Group Leader

Research topic: Applied Biocatalysis



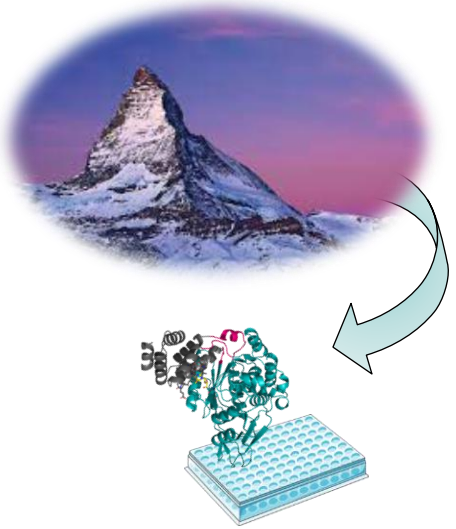
- ✔ High substrate selectivity
- ✔ Combination of enzymes in one pot
- ✔ Mild reaction conditions (temperature, pH)
- ✔ Biodegradable

- ✖ Low stability under harsh conditions
- ✖ Short operational stability
- ✖ Poor reusability

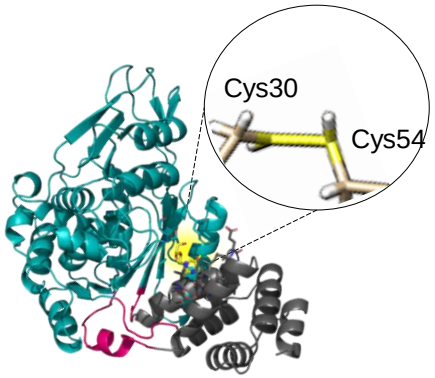
How to make Biocatalysis more sustainable and efficient?

Enhancing the stability of enzymes

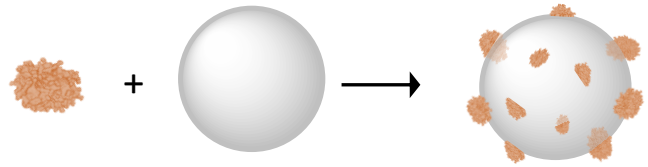
Enzyme discovery from extremophiles



Protein engineering



Enzyme immobilization

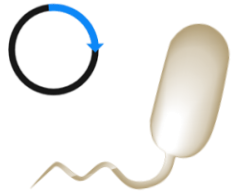


Benítez-Mateos *et al.* **2022** *Nat. Chem.* 14: 489-499.
Benítez-Mateos **2024** *CHIMIA. 78*: 222-225.

Project 1

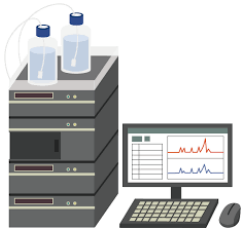
Enzyme discovery from extremotolerant organisms

Identification of new enzymes



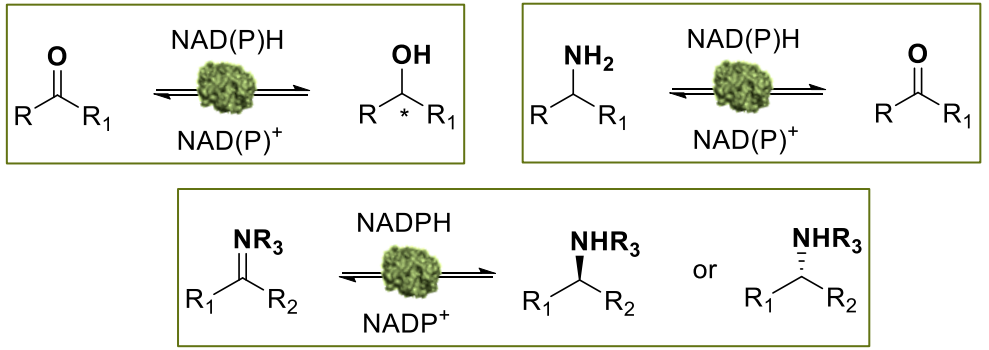
Heterologous expression and protein purification

Biotransformations

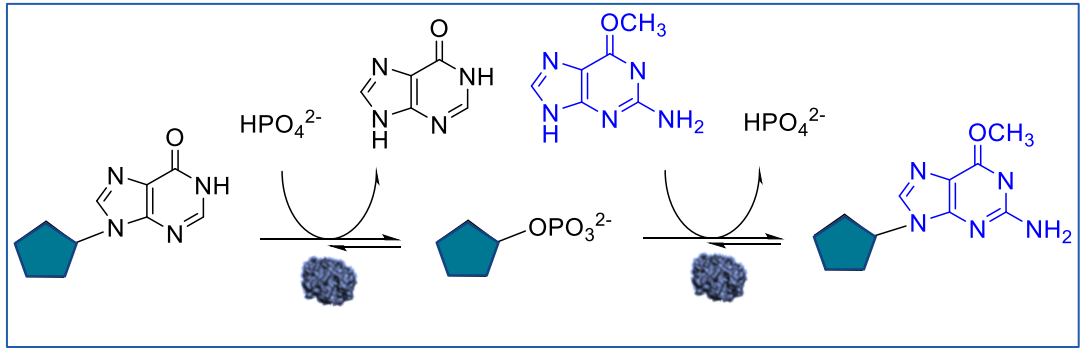


Analysis

Redox enzymes



Phosphorylases



Benítez-Mateos & Paradisi. **2022** *ChemSusChem.* 15: e2021020.
Stalder *et al.* **2024** *ChemCatChem e202301671*.

Project 2

Protein engineering to develop more robust enzymes

Molecular Biology

- Gibson assembly
- Site-directed mutagenesis

Fusion proteins

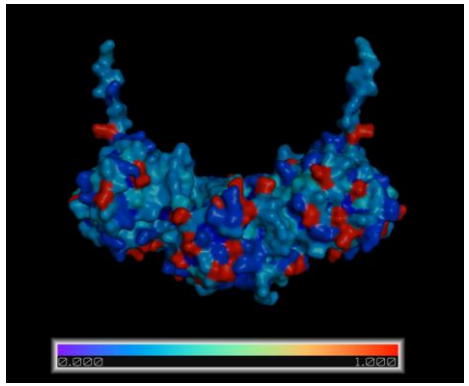
- Bioinformatic analysis
- Expression of fusion enzymes
- Optimization of protein purification
- Structural analysis (CD spectroscopy, DLS)

- Activity assays
- Stability test
- Enzyme kinetics

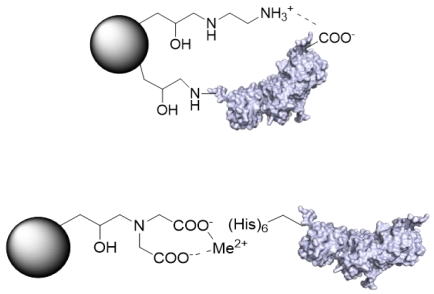
Marchini *et al.* **2022** *ChemBioChem. e202200428.*

Project 3

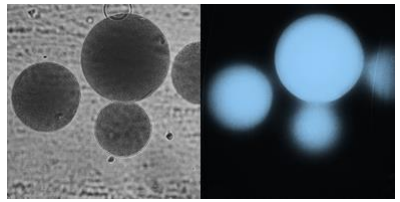
New approaches for enzyme immobilization



Bioinformatic analysis of protein structures
(Chimera, Pymol, CapiPy)



Screening of immobilization chemistries and materials



Microscopy analysis

Collaborations with:

CIC bioma GUNE
Biomaterialetako Ikerkuntza Kooperatiboko Zentroa
Centro de Investigación Cooperativa en Biomateriales

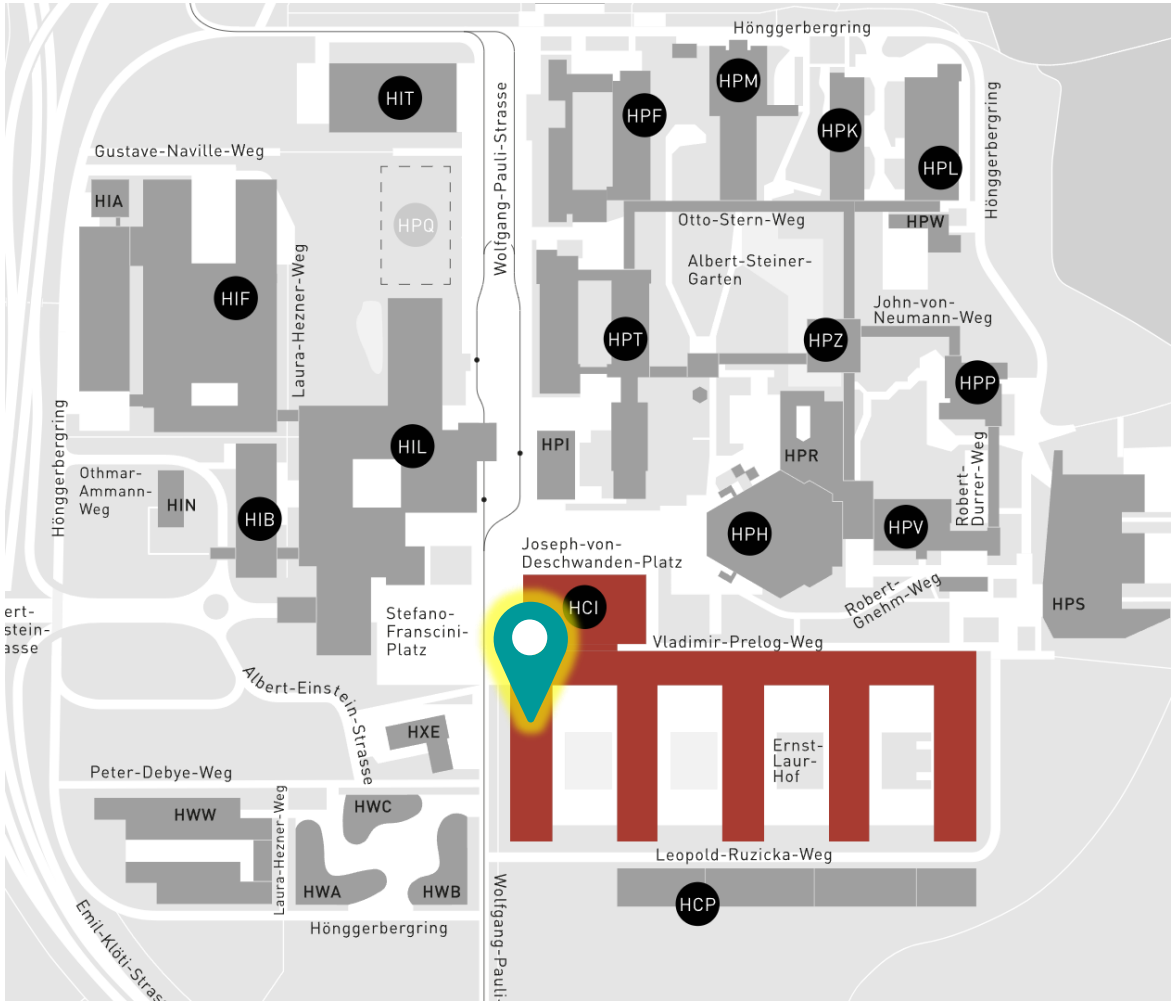
Prof. Fernando López-Gallego (Spain)

inseit
BIOCATALYST IMMOBILIZATION

inSEIT (University of Bern)

Roura Padrosa *et al.* **2021** *Bioinformatics. 37:* 2761-2762.
Santiago-Arcos *et al.* **2024** *ACS Sus. Chem. Eng. 12:* 9474-9489.

Where?



Campus Hönggerberg

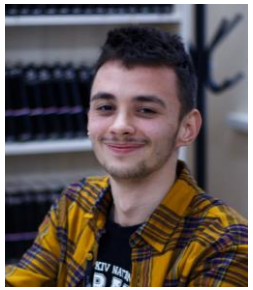
HCI Building

Labs: **G130-G132**

Office: **G125**

Thanks to:

Our team



Yevhenii Kostenko
PhD student

Sofia L. Hutter

Julia Arnold

The Arosio group (our host and colleagues)

Join us!

ana.benitez-mateos@chem.ethz.ch

www.benitezmateos.com

Swiss National Science Foundation

Bringing Materials to Life | BML

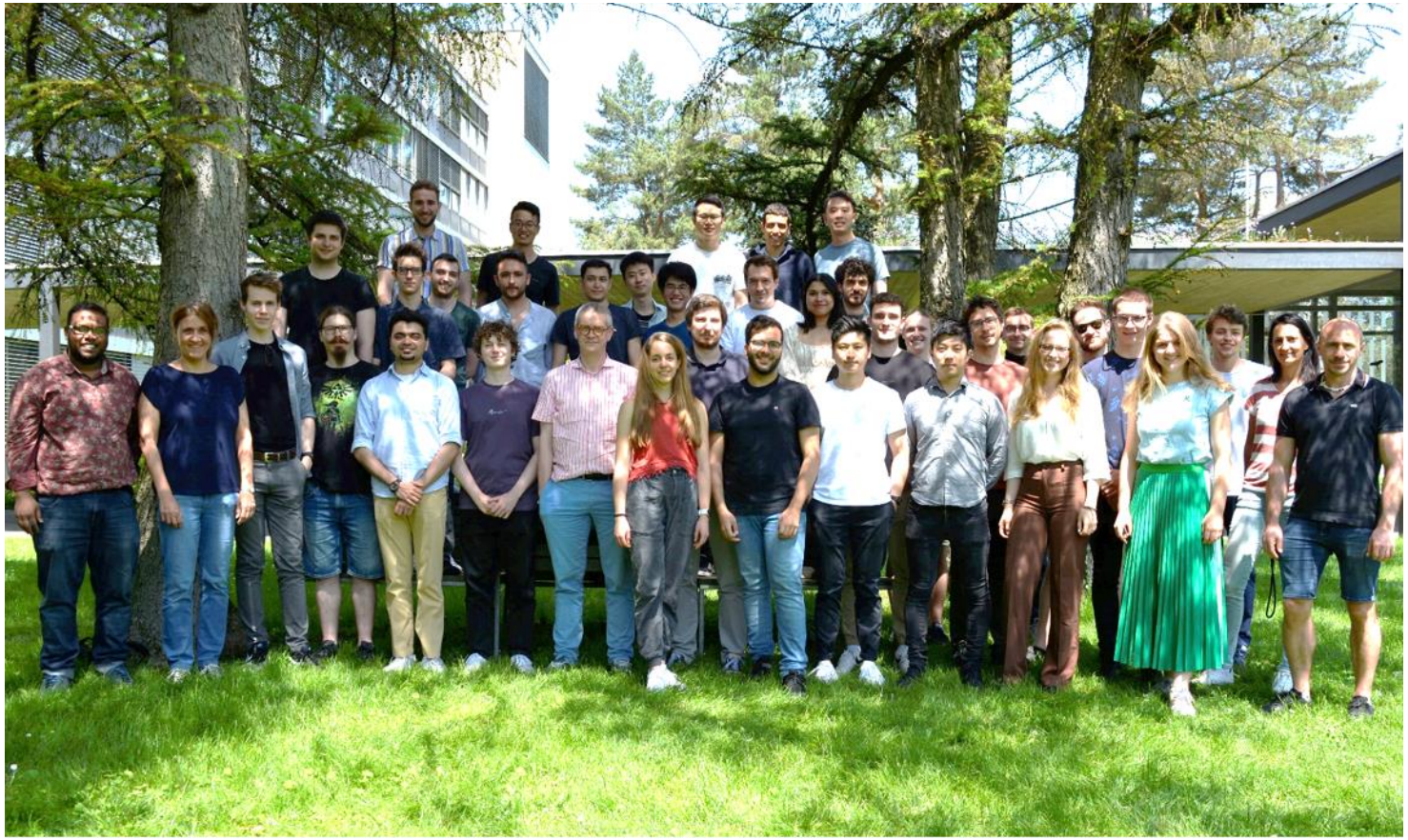
ETH zürich

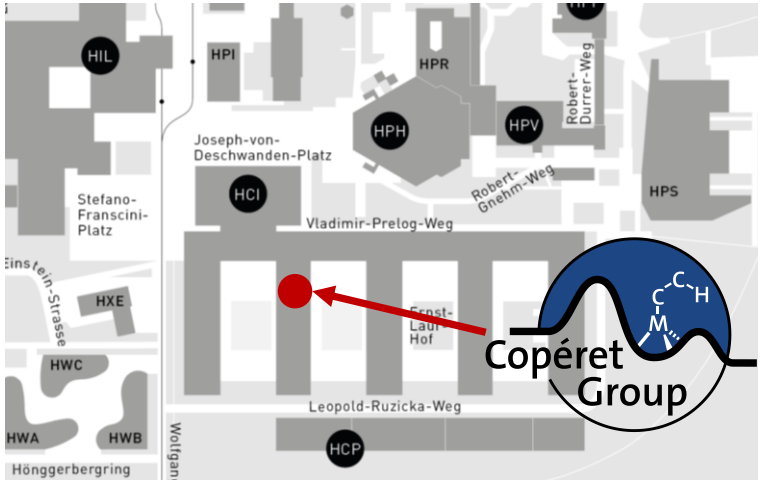
Research in the Copéret Group: Catalysis and Sustainable Chemistry using Molecular Principles

Colin Hansen, PhD Student

11.12.2024

The Copéret Group
Who are we?

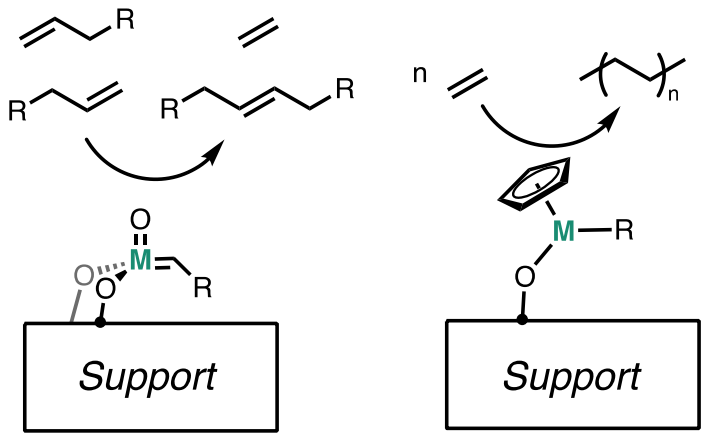




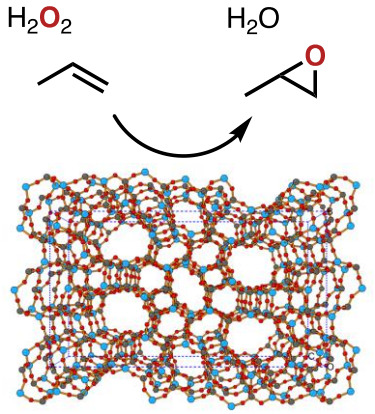
- ***Prof. Christophe Copéret***
- ***Dr. Alexander Yakimov***
- ***Dr. Milivoj Plodinec***
- ***6 Postdocs***
- ***22 PhD Students***
- ***5-15 Semester students / year***
- ***2-3 Master students / year***

The Big-Picture
What makes a good catalyst – what determines reactivity?

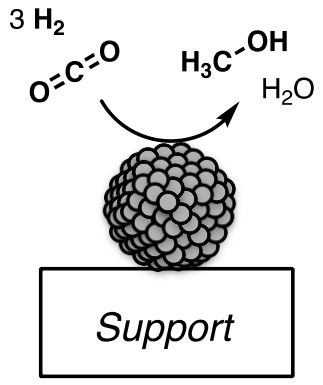
Investigating large scale reactions for a more sustainable future

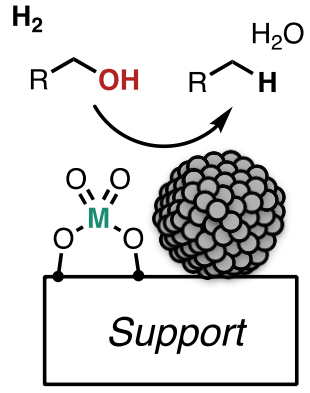


Surface Sites



Zeolite Catalysts

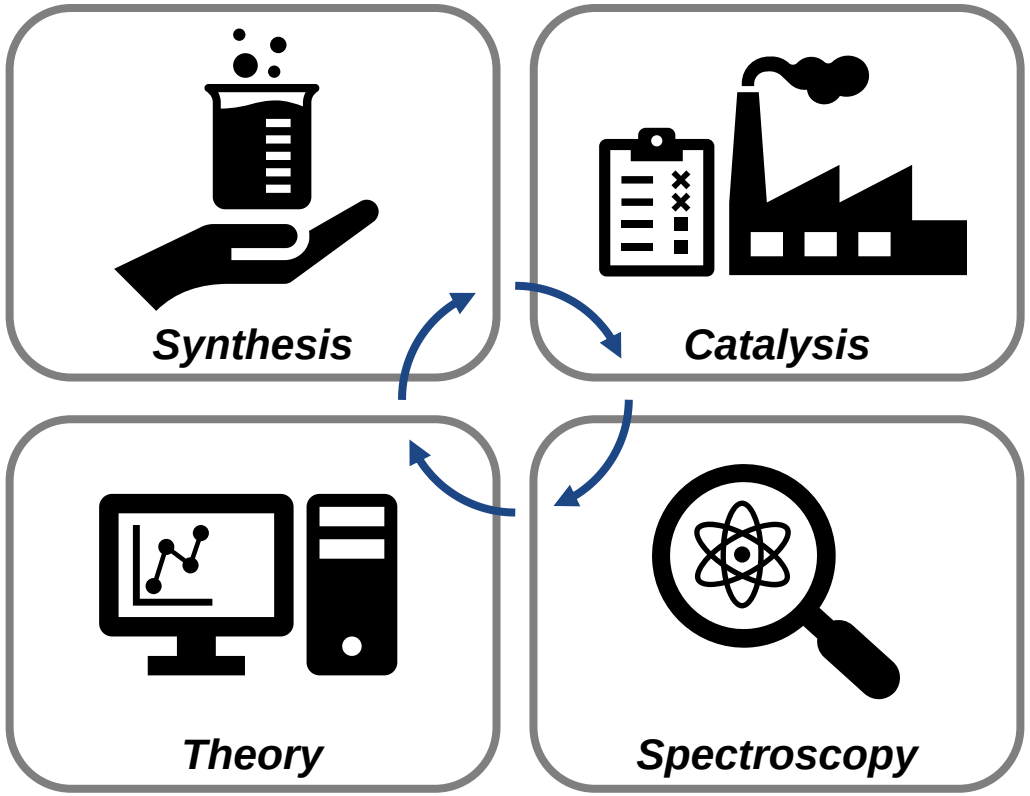




Supported Metal Nanoparticles

Copéret et al., *Angew. Chem. Int. Ed.* **2018**, 57, 6398-6440

Working in the Copéret-Group



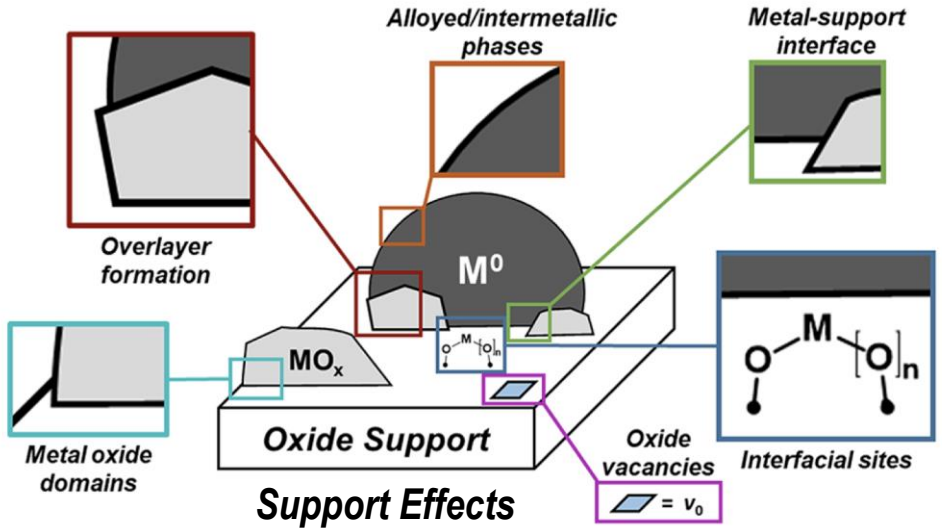
Surface Organometallic Chemistry (SOMC)

Organometallic chemistry principles applied to synthesis of tailored materials

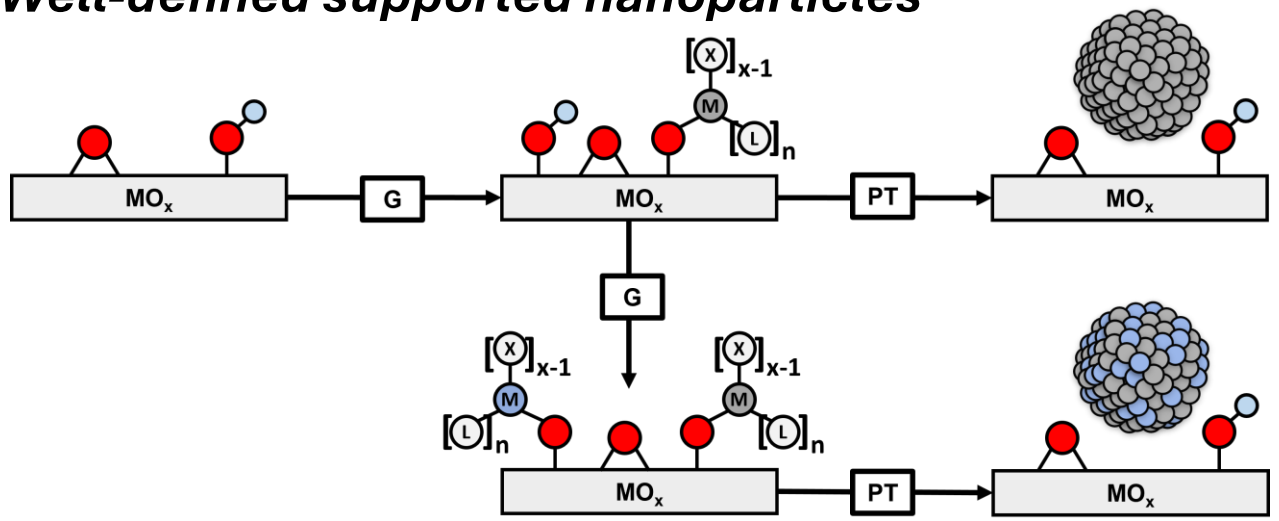
Copéret Group

Synthesis

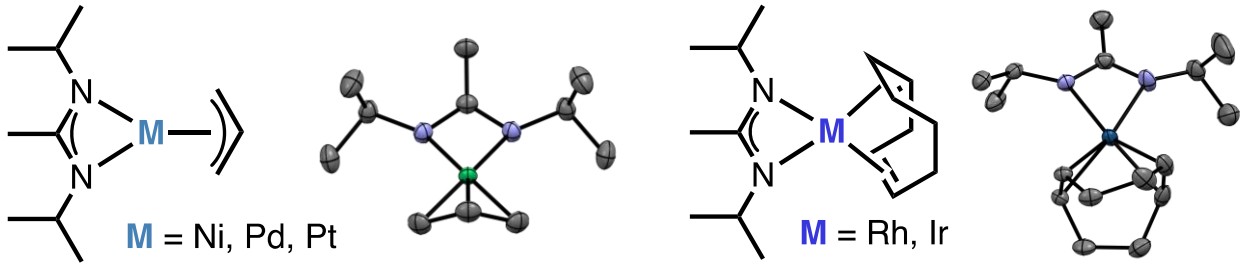
Surfaces are complex!



Well-defined supported nanoparticles



Development of novel molecular precursors



Docherty et al., *J. Am. Chem. Soc.* **2021**, 143, 6767–6780
Ehinger et al., *JACS Au* **2023**, 3, 2314−2322.

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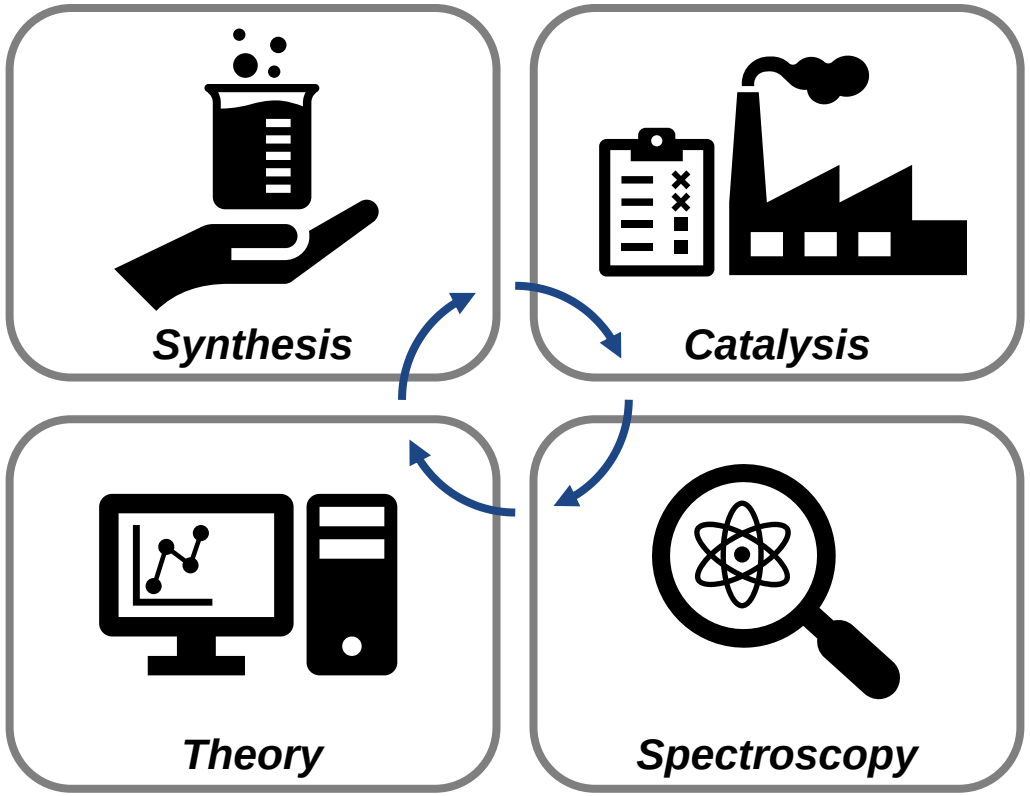
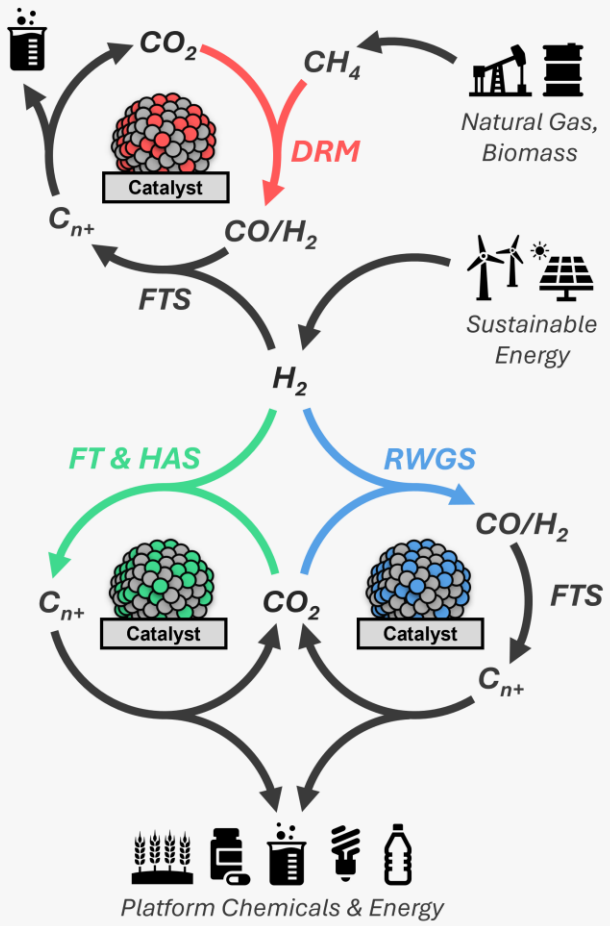


Catalysis
Testing catalytic activity in a plethora of reaction conditions



In the Copéret-Group we work on...

...Syngas production.

Reverse Water-Gas Shift (RWGS):

$CO_2 + H_2 \longrightarrow CO + H_2O$

Dry Reforming Methane (DRM):

$CH_4 + CO_2 \longrightarrow 2\,CO + 2\,H_2$

...Syngas utilization.

Syngas-to-Methanol:

$CO + 2\,H_2 \longrightarrow CH_3OH$

FTS to Olefins, Paraffins:

$n\,CO + 2n\,H_2 \longrightarrow C_nH_m + n\,H_2O$

FTS to Higher Alcohols:

$n\,CO + 2n\,H_2 \longrightarrow C_nH_{2n+1}OH + n\text{-}1\,H_2O$

...CO_2 utilization.

CO_2 to Methanol:

$CO_2 + 3\,H_2 \longrightarrow CH_3OH + H_2O$

CO_2 Methanation:

$CO_2 + 4\,H_2 \longrightarrow CH_4 + 2\,H_2O$

CO_2 to Olefins and Paraffins:

$n\,CO_2 + 3n\,H_2 \longrightarrow C_nH_m + 2n\,H_2O$

CO_2 to Higher Alcohols:

$n\,CO_2 + 3n\,H_2 \longrightarrow C_nH_{2n+1}OH + 2n\text{-}1\,H_2O$

Catalysis

Many industrial/academic collaborators!

NCCR Catalysis

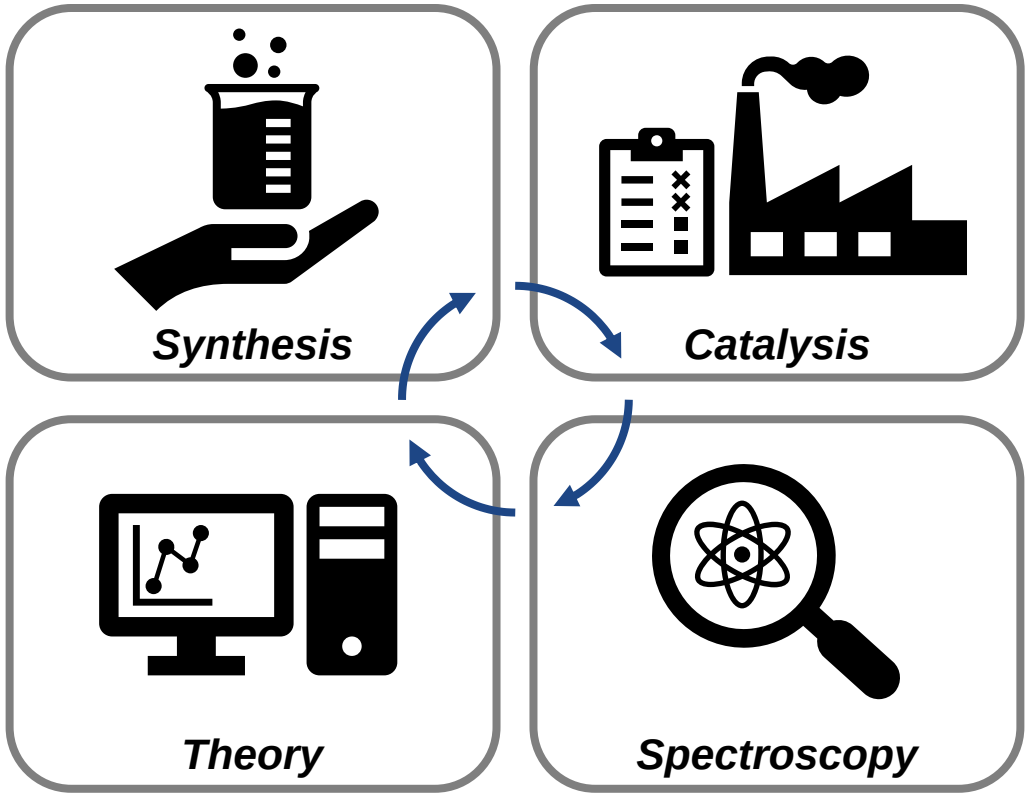
CAT

BASF We create chemistry

bp

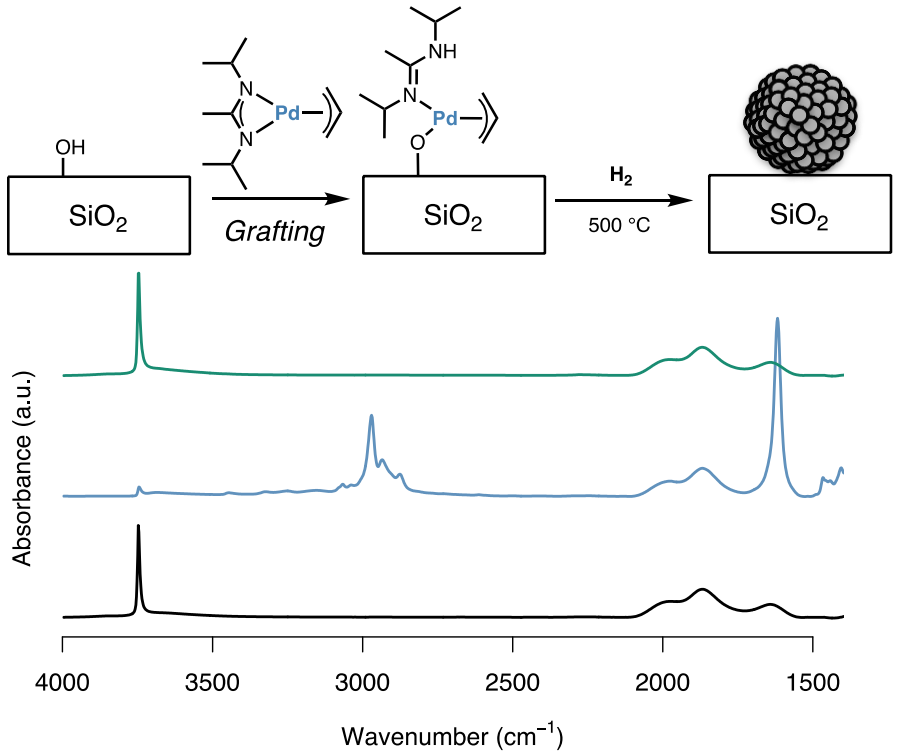
CLARIANT

Working in the Copéret-Group

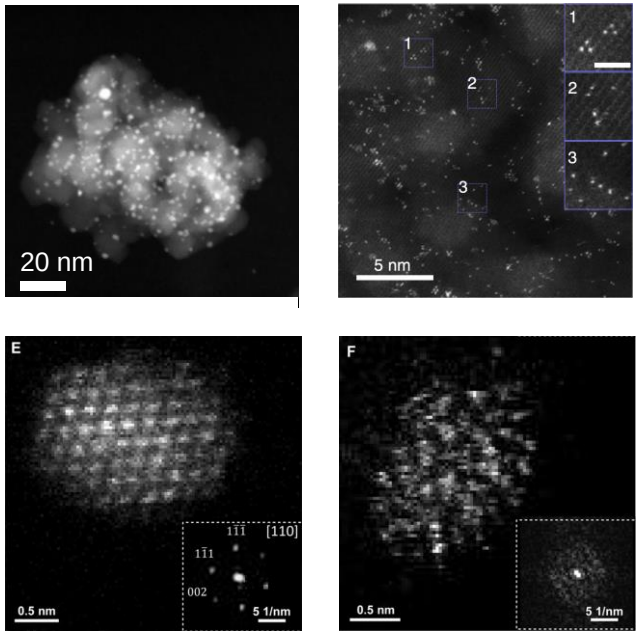


Spectroscopy
An array of characterization techniques to understand surfaces

IR Spectroscopy



Electron Microscopy



... and Solid-state NMR, probe molecules, chemisorption, physisorption, X-Ray diffraction, X-Ray adsorption, DRIFTS, cyclic voltammetry ...

Spectroscopy

Ehinger et al., *JACS Au* **2023**, 3, 2314−2322.
Brack et al., *Chem. Sci.* **2023**, 14, 12739-12746

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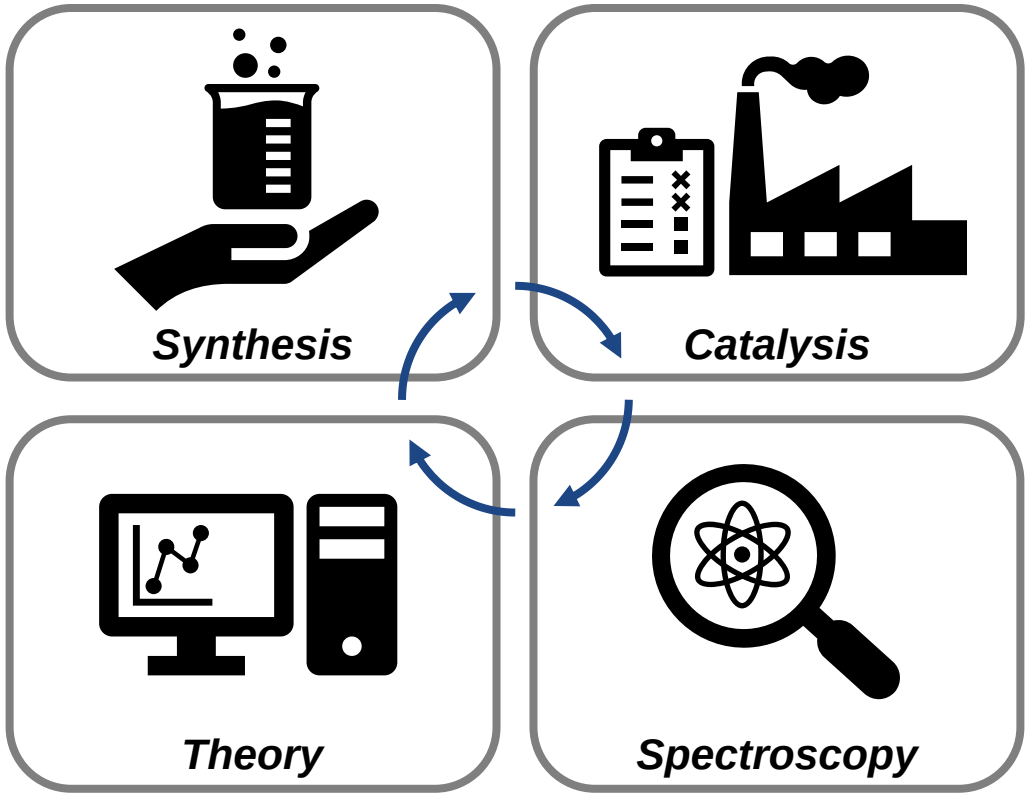
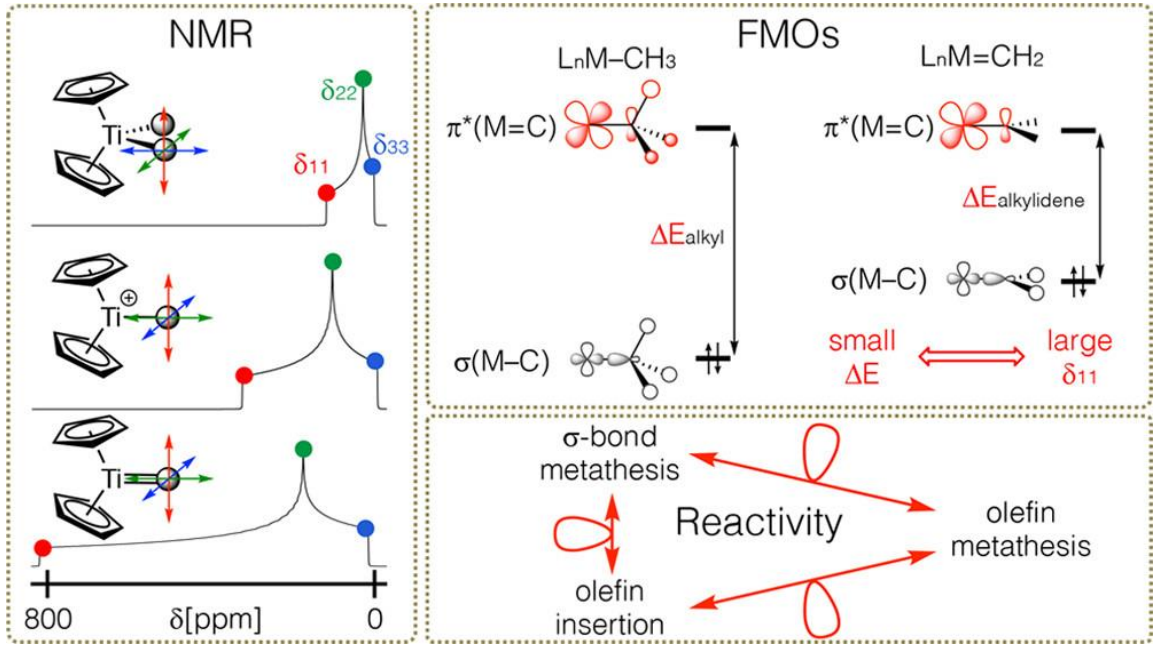


Computational Chemistry and HTE

Computer assisted development of models and automatization

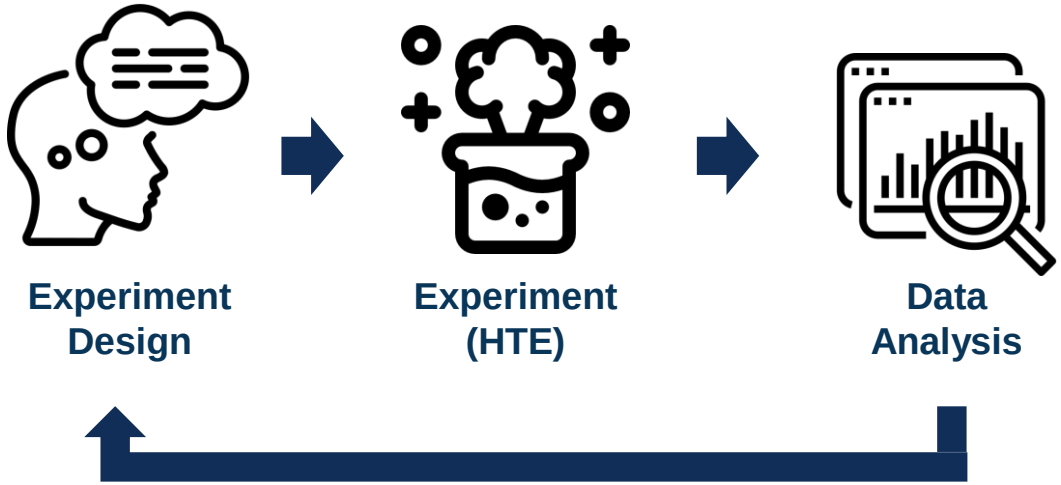
Understanding spectroscopic signatures



Theory

NMR signature = Reactivity descriptor

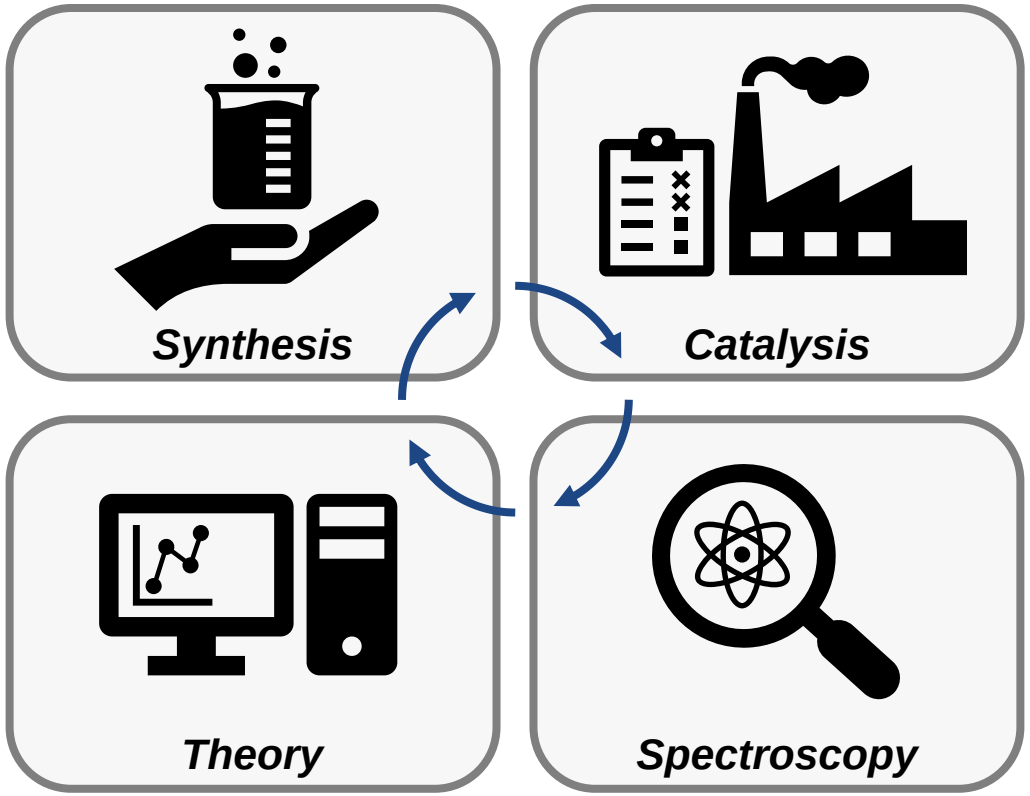
Hight-throughput experimentation



Accelerated discovery and automatization

Gordon et al., *Acc. Chem. Res.* **2019**, 52, 2278-2289.
Ramirez et al., *Chem Catalysis* **2024**, 4, 100888

Working in the Copéret-Group



Copéret Group

90	11	19
Th	Na	K
Thorium	Sodium	Potassium
232.038	22.990	39.098

39	8	92
Y	O	U
Yttrium	Oxygen	Uranium
88.906	15.999	238.029

Schweizerischer Nationalfonds

NCCR Catalysis

ETH AI CENTER

CAT

BASF We create chemistry

bp

CLARIANT

IFP Energies nouvelles

ETH zürich

For further questions:

Colin Hansen

chansen@ethz.ch

Interested? Reach out directly to:

Prof. Christophe Copéret

ccoperet@ethz.ch

Send us your:

CV, Letter of Motivation, Transcript

To ***ccoperet@ethz.ch***

coperetgroup.ethz.ch

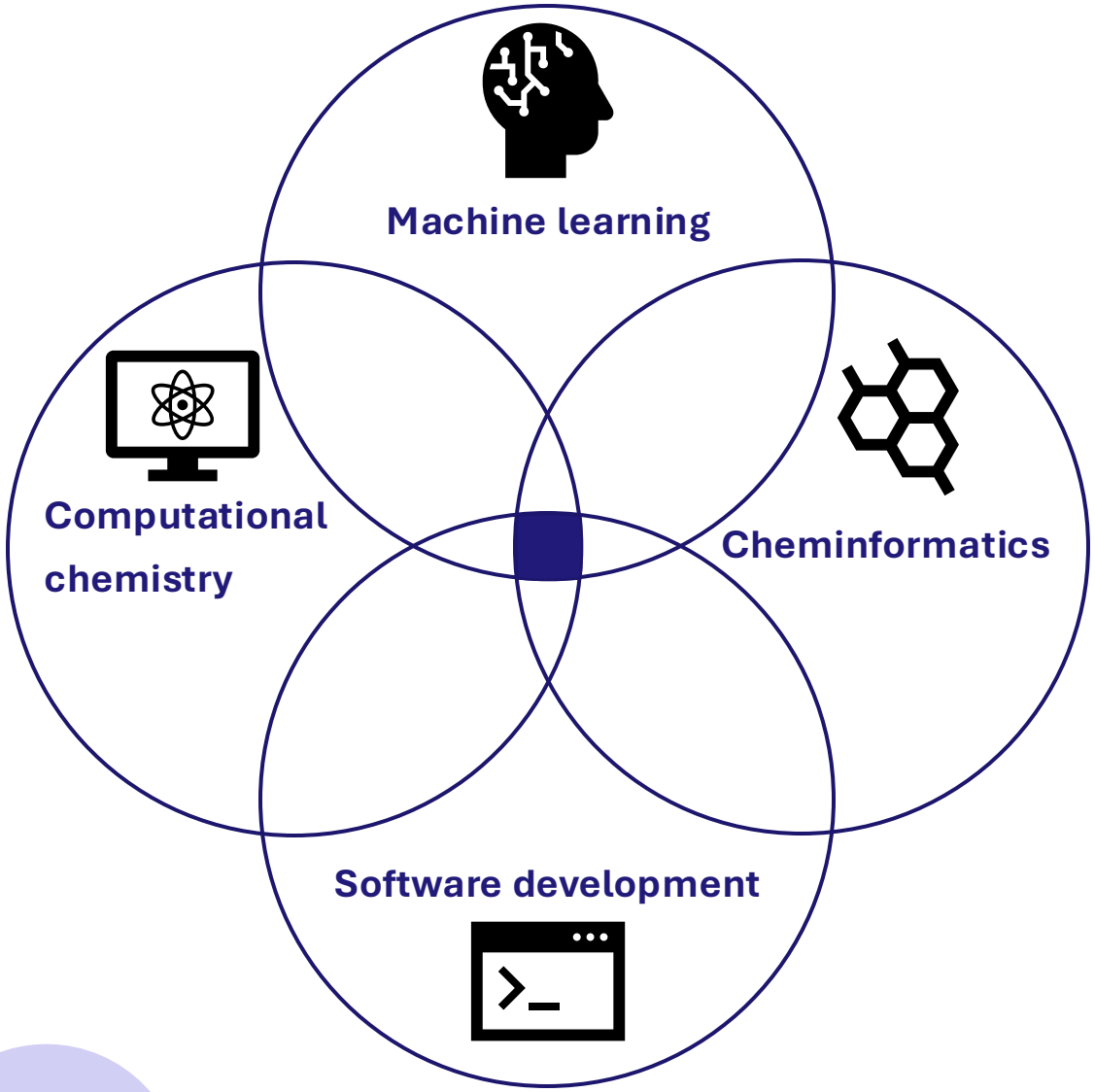
Digital Chemistry Laboratory
Prof. Kjell Jorner

VCS research project info-event

Franziska Weissbach & Zarko Ivkovic

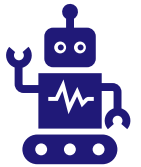
ETH zürich

Digital Chemistry



Lab chemists

High-throughput experimentation



Self-driving labs

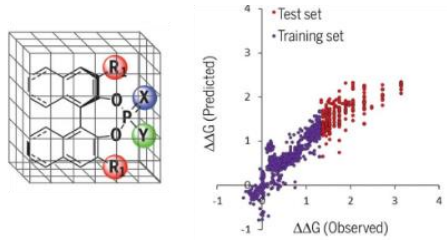
Mission: Accelerate chemical discovery with digital tools

Strategic core research

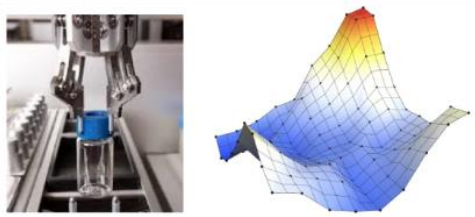
Opportunity-driven

Reactivity and catalysis

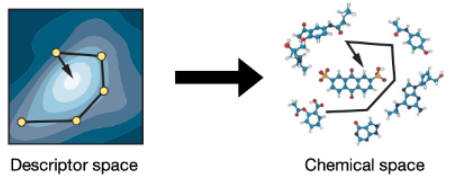
Reaction outcome prediction



Reaction optimization

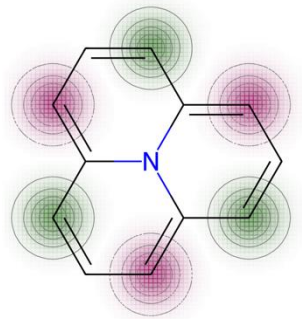


Catalyst & reaction design

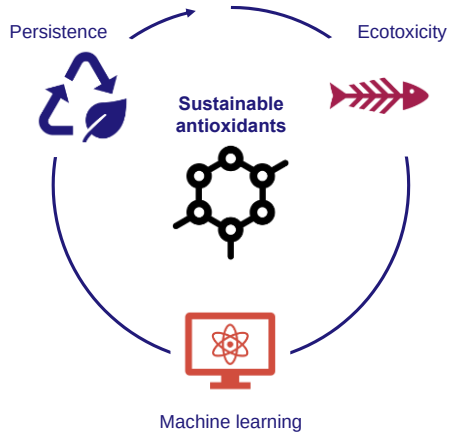


Computer-aided molecular design

Organic electronic materials



Safe and sustainable by design



NCCR Catalysis

Our niche: Models in the low-data regime

Simulations

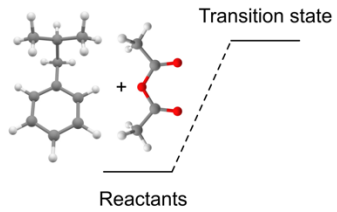
Chemistry-informed machine learning

Machine learning

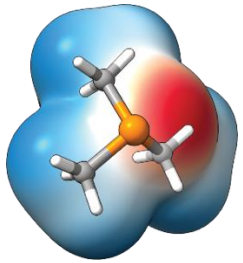
No data

Lots of data

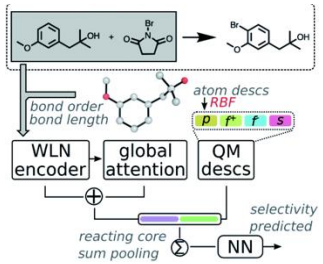
Mechanistic DFT



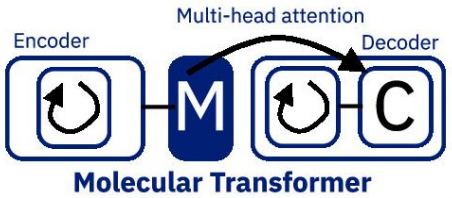
Chemical descriptors



Chemistry-augmented deep learning



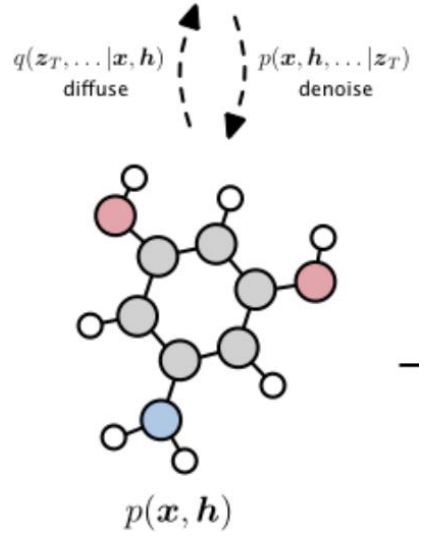
Deep learning



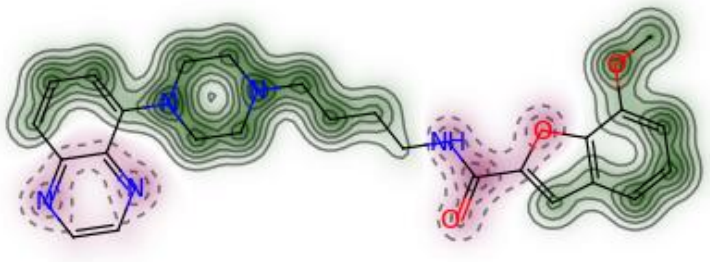
Examples of recent student projects

Generating descriptors of amino acid rotamers for machine learning

Fine-Tuning of Diffusion Models for Molecule Generation



Integrating numerical descriptors into language models for property prediction



Molecular conformer generation for macrocycles using torsional diffusion

The Digital Chemistry Laboratory

Department of Chemistry and Applied Biosciences (D-CHAB)
Institute of Chemical and Bioengineering (ICB)

Principal investigator
Prof. Dr. Kjell Jorner

PhD students
Lauriane Jacot-Descombes
Giustino Sulpizio
Stefan Schmid
Luca Schaufelberger
Franziska Weißbach
Zarko Ivkovic
Ghali Sekkat

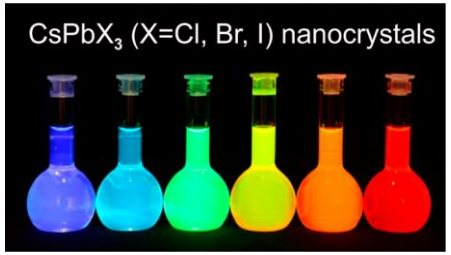
Co-supervised PhD students
Vignesh Ram Somnath (w. Prof. Krause)
Riccardo De Santi (w. Prof. Krause, He)

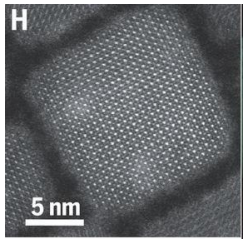
Contact us!
fweissbach@ethz.ch
zivkovic@ethz.ch
HCI E133-135

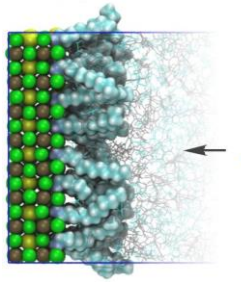
@DCL_ETHZ

The Kovalenko group

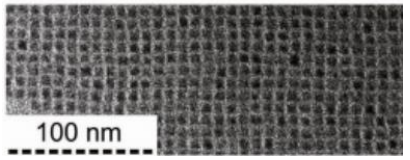
Color tuning by composition



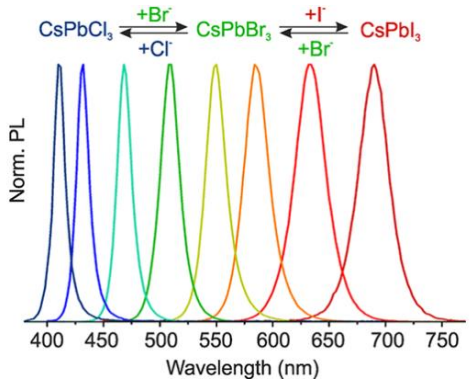




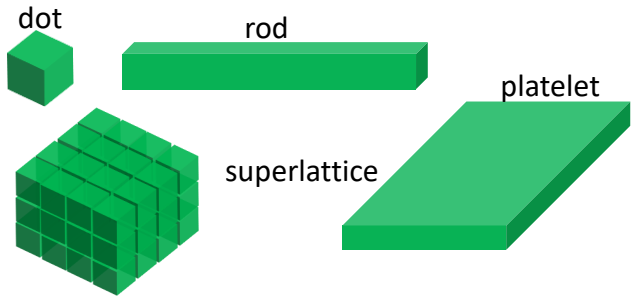
Ligand-surface engineering



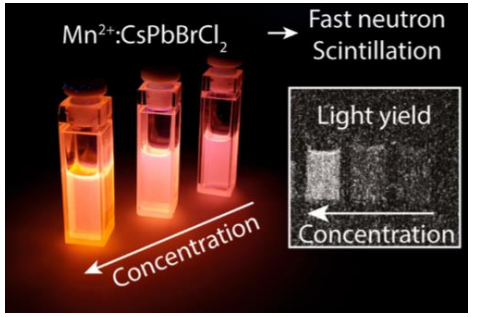
NC assemblies



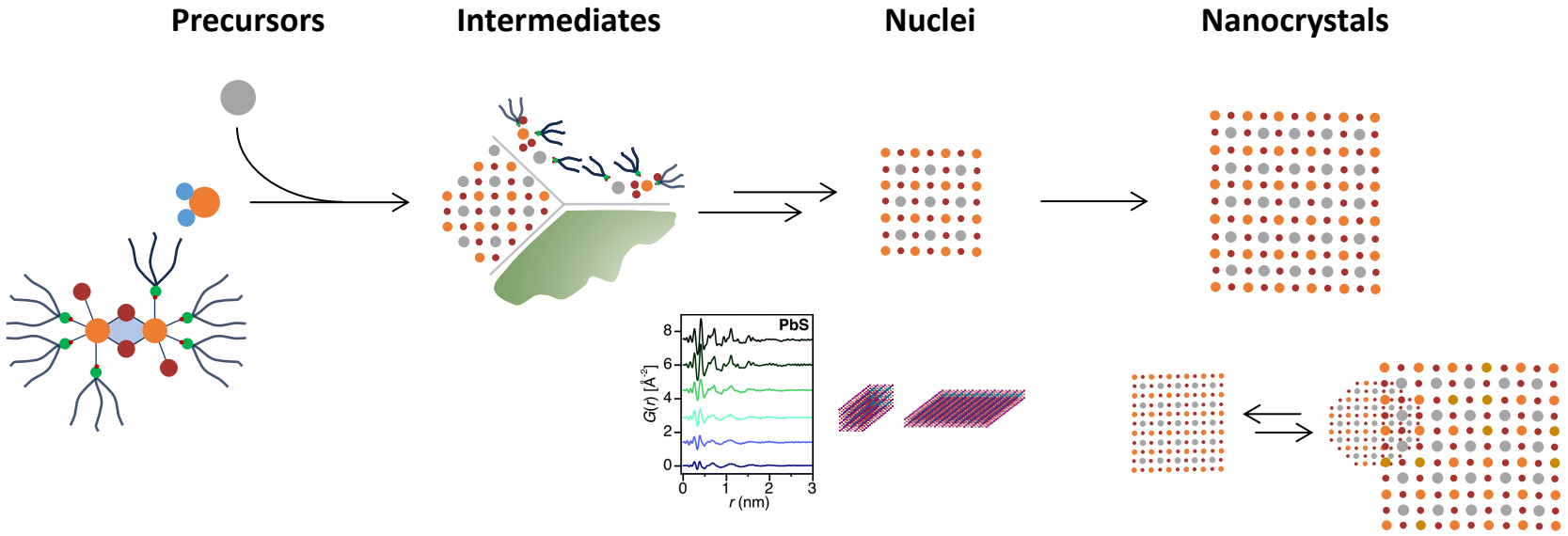
Various nanostructures



Neutron imaging



X-ray: Studying the Formation Mechanism of Nanocrystals

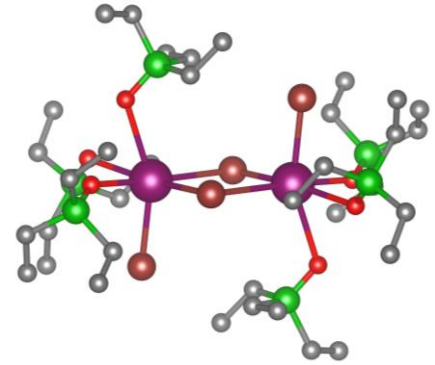


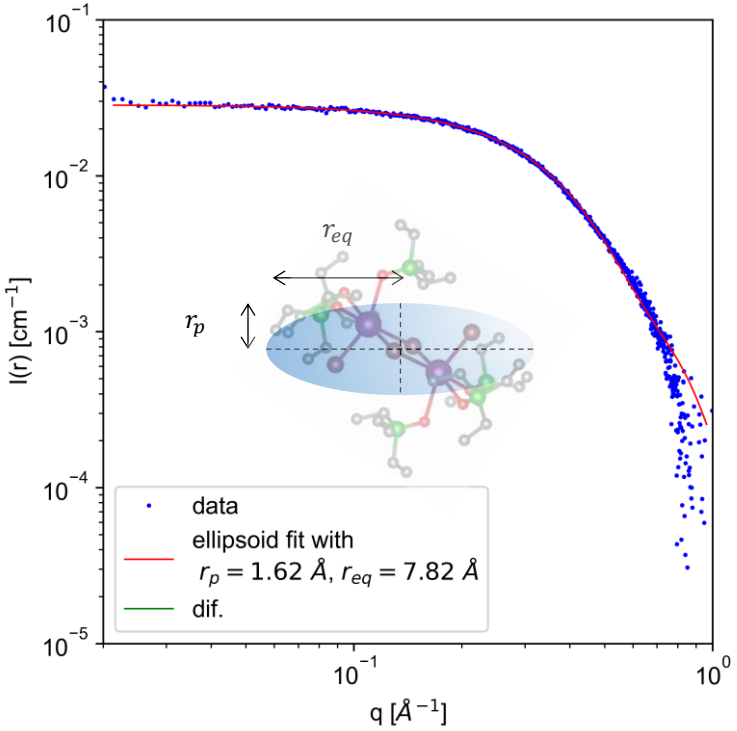
Formation mechanism
1. Precursor's structure and reactivity
2. Intermediates identification
3. Kinetic study
4. Confrontation with other ABX_3

Anisotropy
1. Process of surface etching by ligand
2. NRs formation
3. NPLs formation

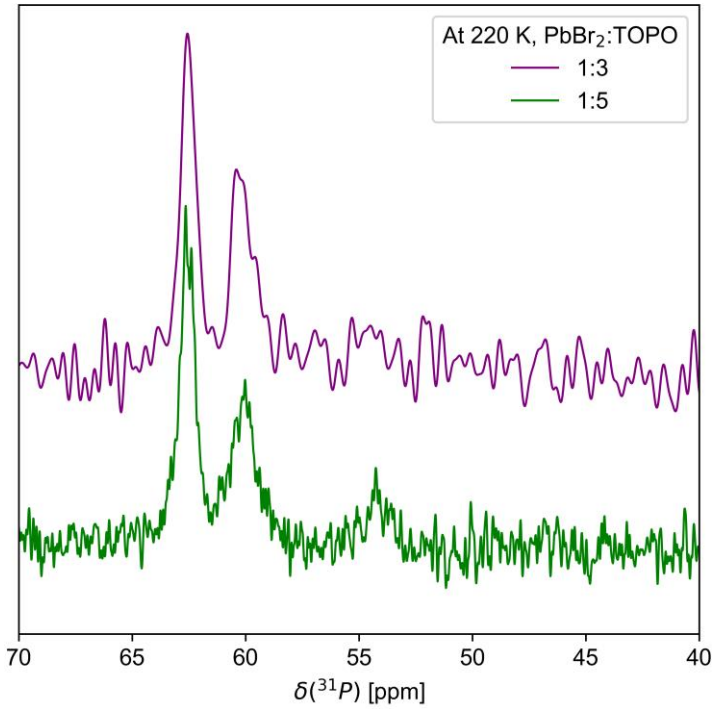
Composition alteration
1. Ion exchange process
2. Doping control

X-ray: Understanding the Nature of the Synthesis Precursors

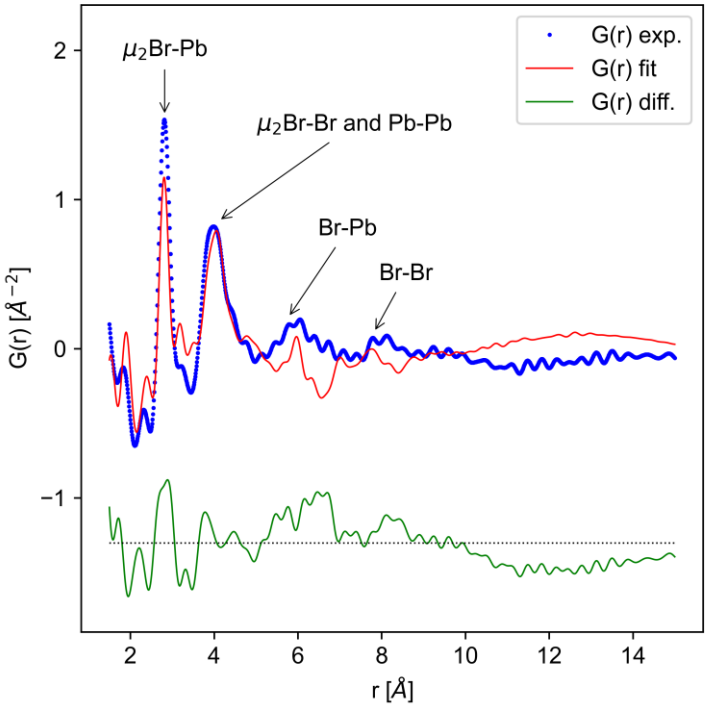




SAXS



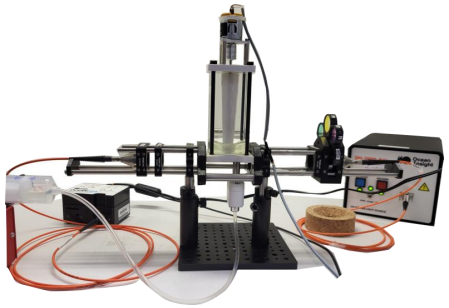
^{31}P-NMR

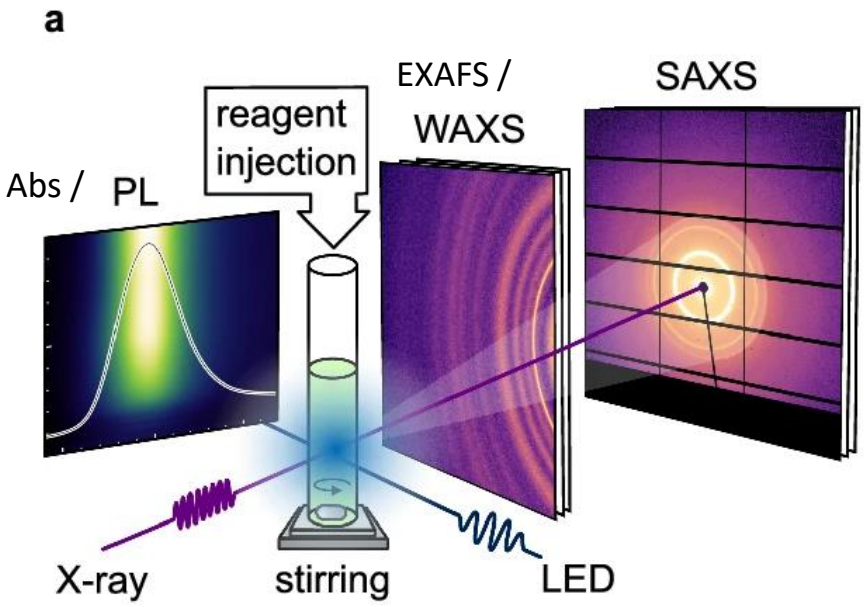


Pair Distribution Function

X-ray: Probing in situ nanocrystal formation

Design reactor for multiple observation
X-ray and optical



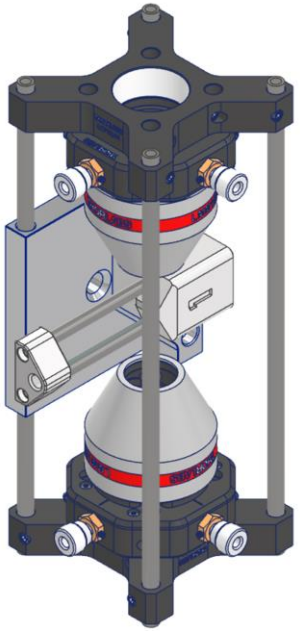


Collecting in situ data
Optical + Synchrotron or NMR

Local structure (EXAFS, NMR, PDF)
Morphology (SAXS, GIWAXS)
Diffuse scattering (PDF)

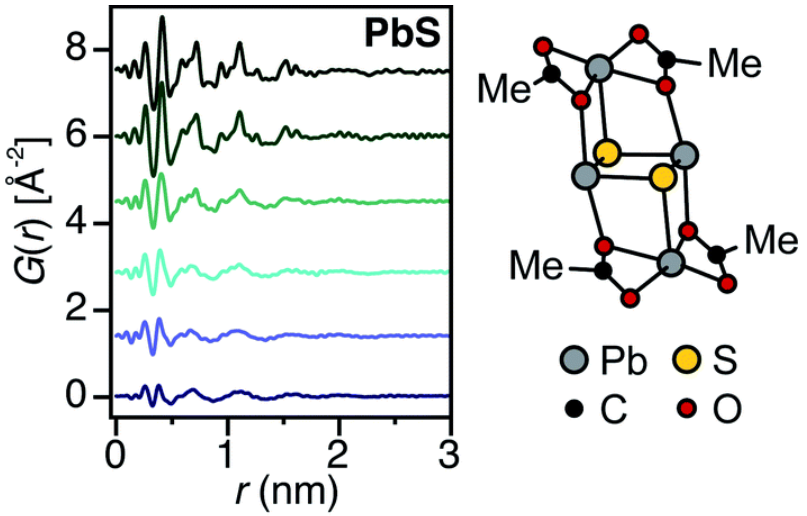
X-ray: Probing in situ the early stage of Nanocrystals Formation

Design reactor for synchronous observation of X-ray and optical



Developing tools for fast synchronous measurement

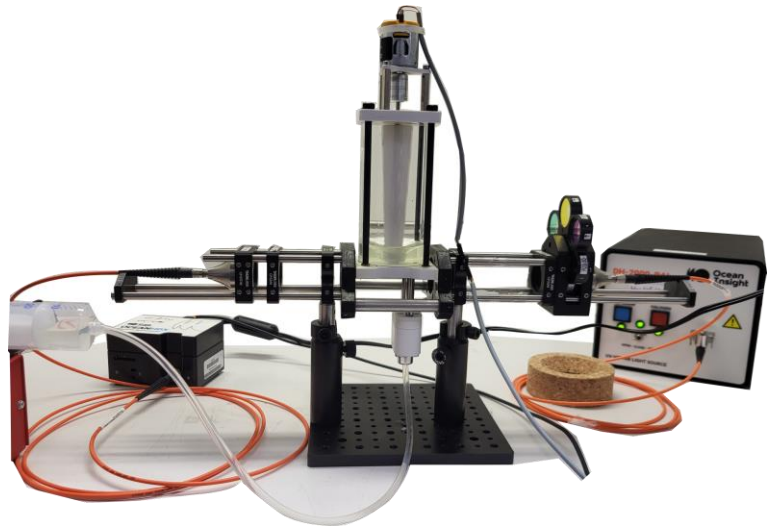
Data analysis
Of advance total X-ray scattering/Pair Distribution Function



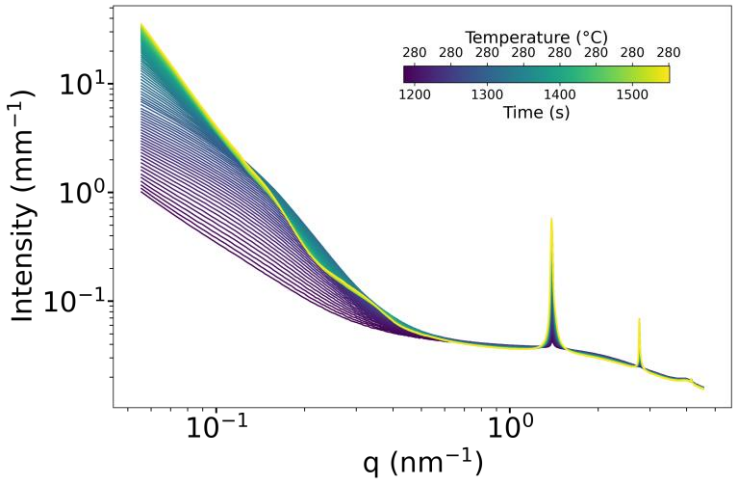
Model development of intermediates

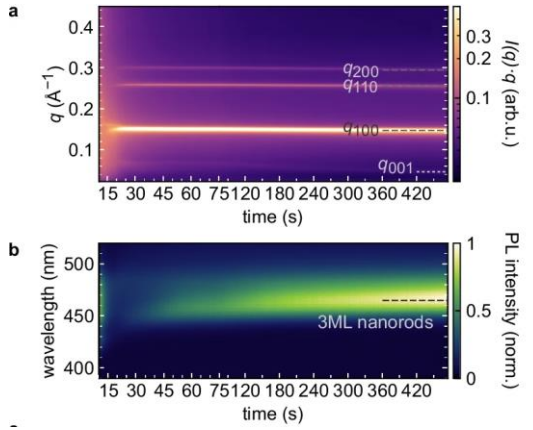
X-ray: Characterizing Anisotropic growth of CsPbBr3 Nanoplatelets and Nanorods

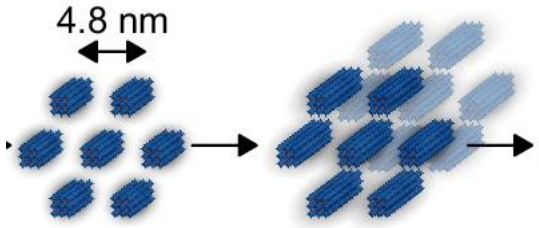
Design reactor for multiple observation
X-ray and optical



Small and Wide-Angle X-ray Scattering (SAXS)



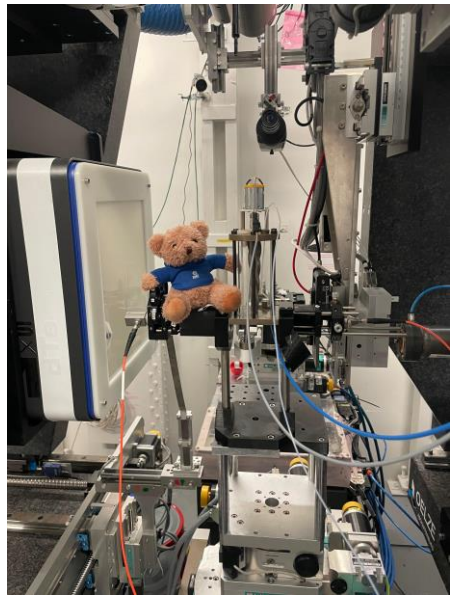


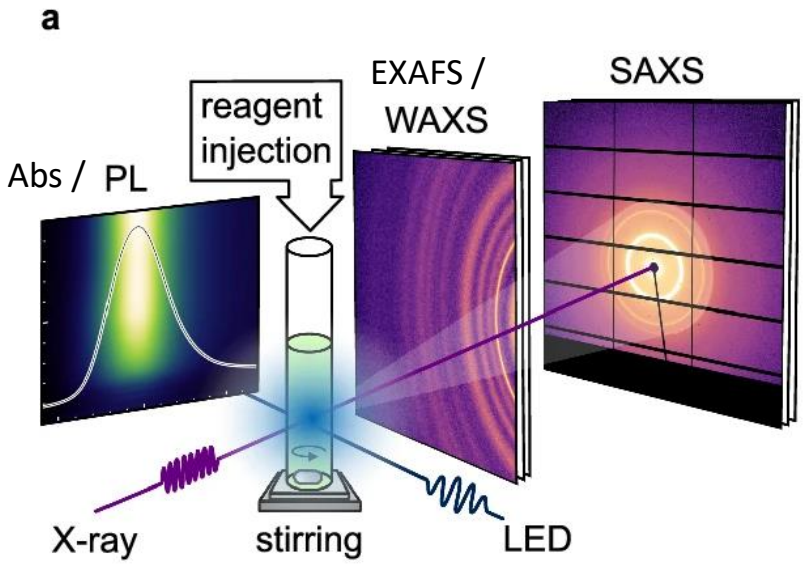


Evolution along time of:

- Morphology
- Assembly

X-ray scattering: advanced tools for *in situ* characterization





Your own ideas for projects are always welcome and

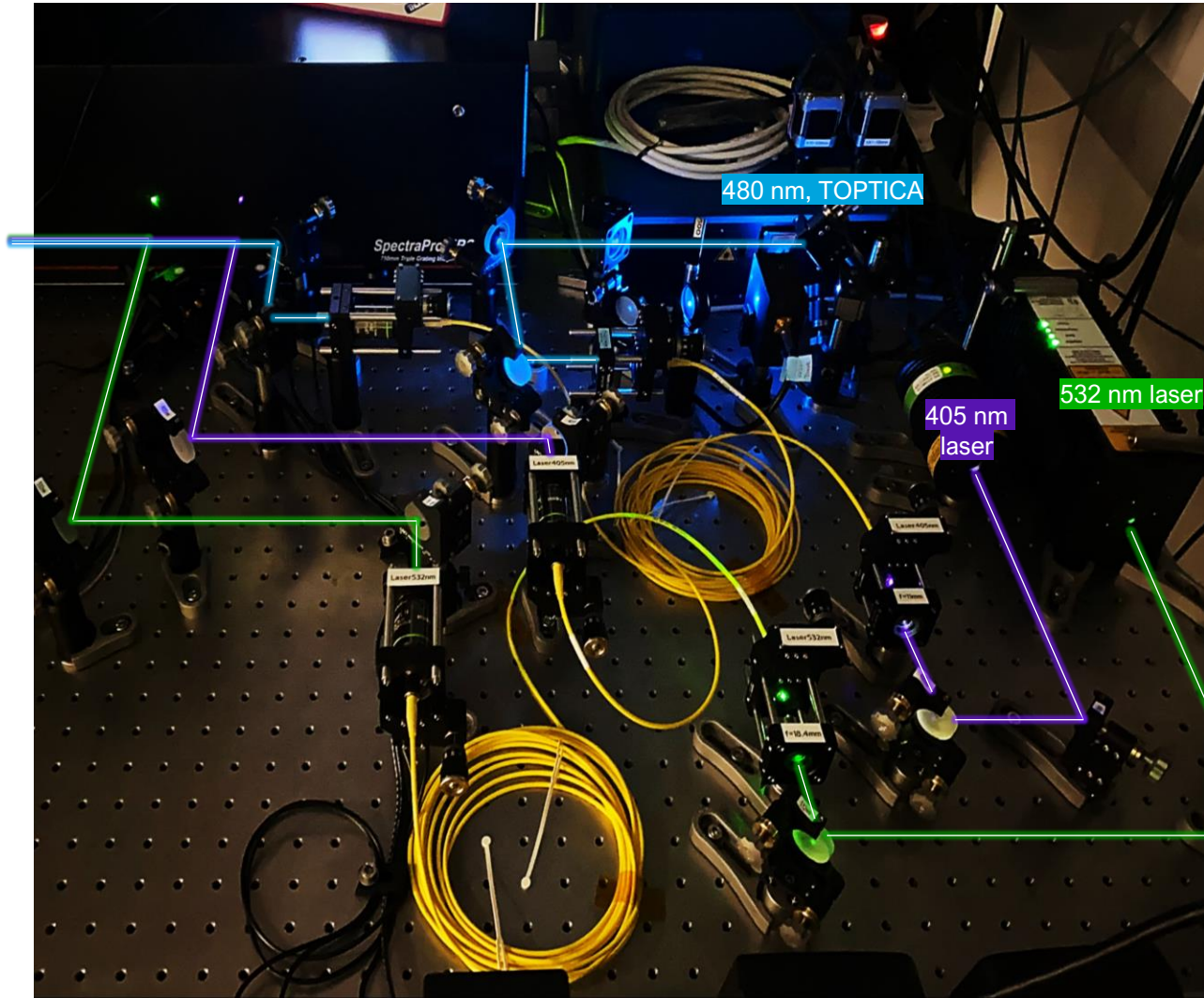
No prior knowledge of SAXS/PDF/EXAFS/NMR/spectroscopy is required!

Just email us (baymoz@ethz.ch) or stop by in H106 for a coffee/chat.

Perovskite Quantum Dots as Single Photon Emitters

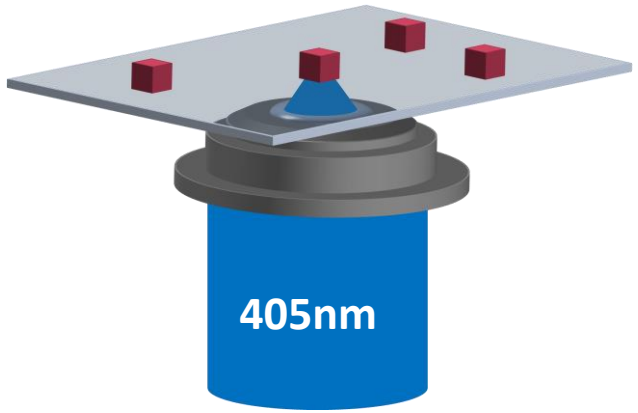
Amrutha Rajan

Kovalenko group / LAC

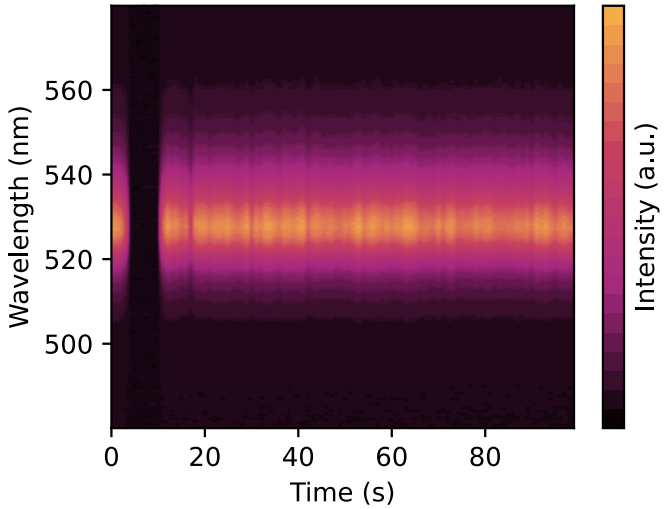


Single-particle Fluorescence Spectroscopy

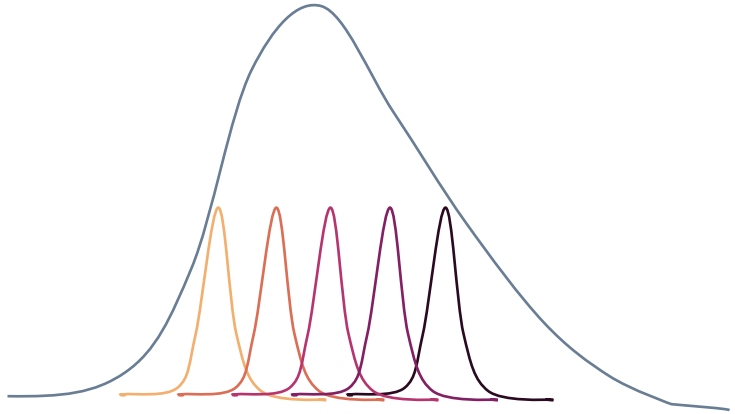
Extremely **diluted film**:
Focus on a single QD



Fluorescence Spectrum over time



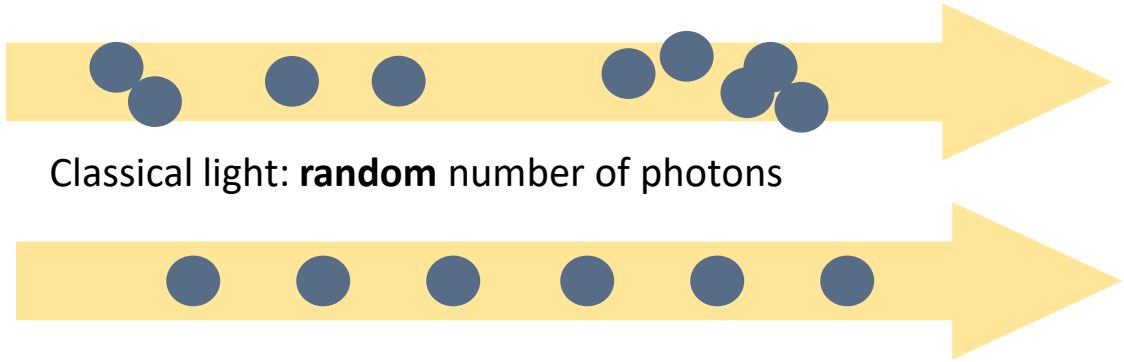
Advantage: **Resolve inhomogeneities**



Study **chemistry** and **physics** of single QDs **under irradiation** (in close collaboration with synthesis lab)

QDs as Single-photon Emitters

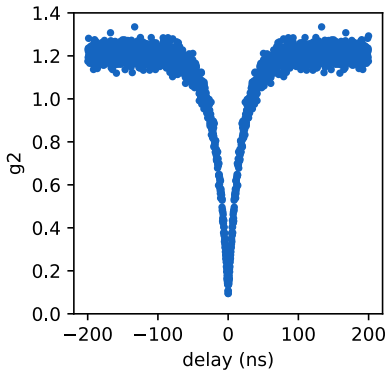
Applications:



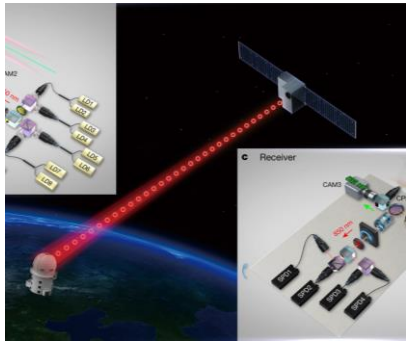
Classical light: **random** number of photons

Quantum light: regular stream of **single photons**

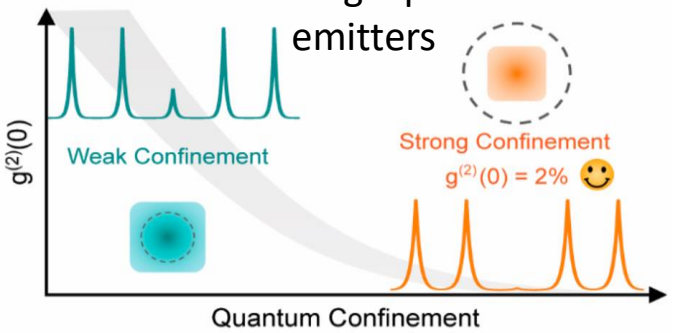
Engineered QDs as bright **quantum light sources**



Quantum **communication**



Single photon emitters



https://doi.org/10.1038/nature23655

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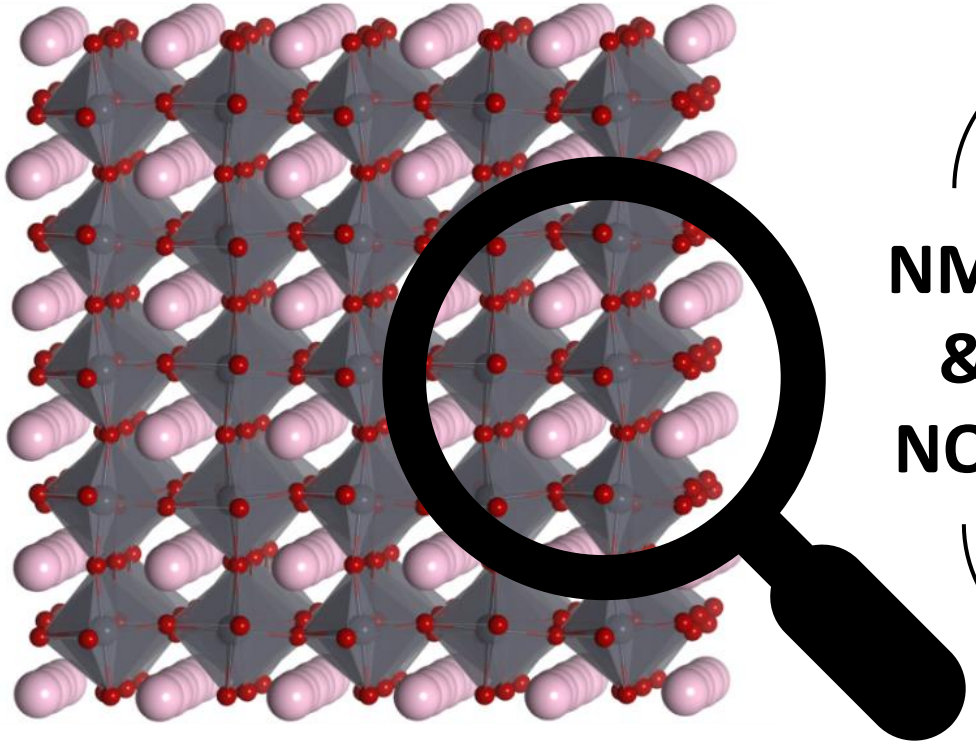
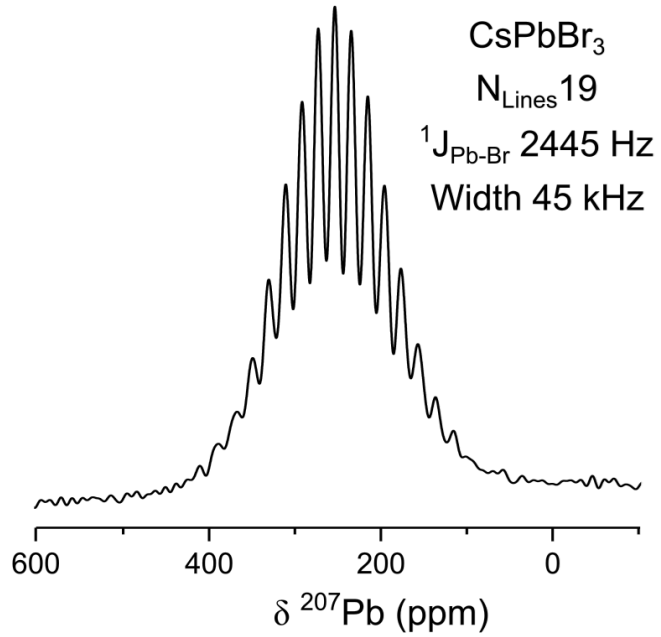
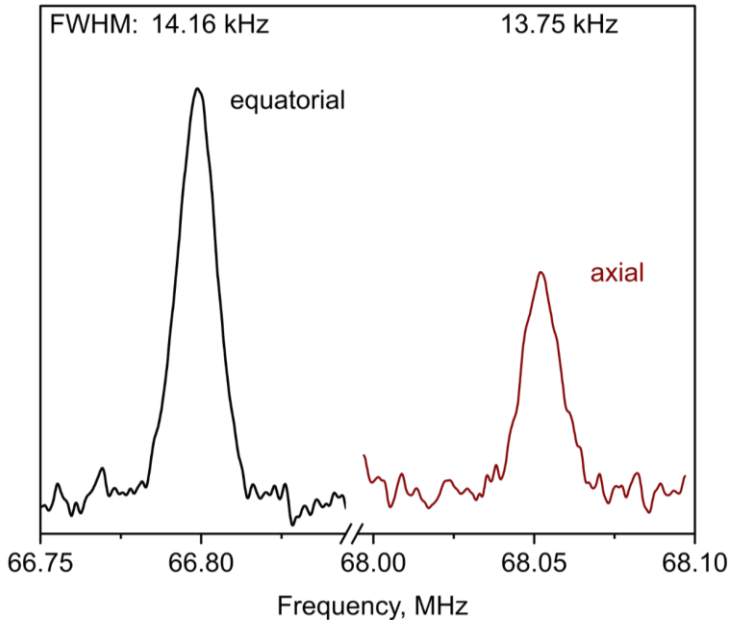
Just email us (arajan@student.ethz.ch) or stop by in H125 for a coffee/chat

ABX_3



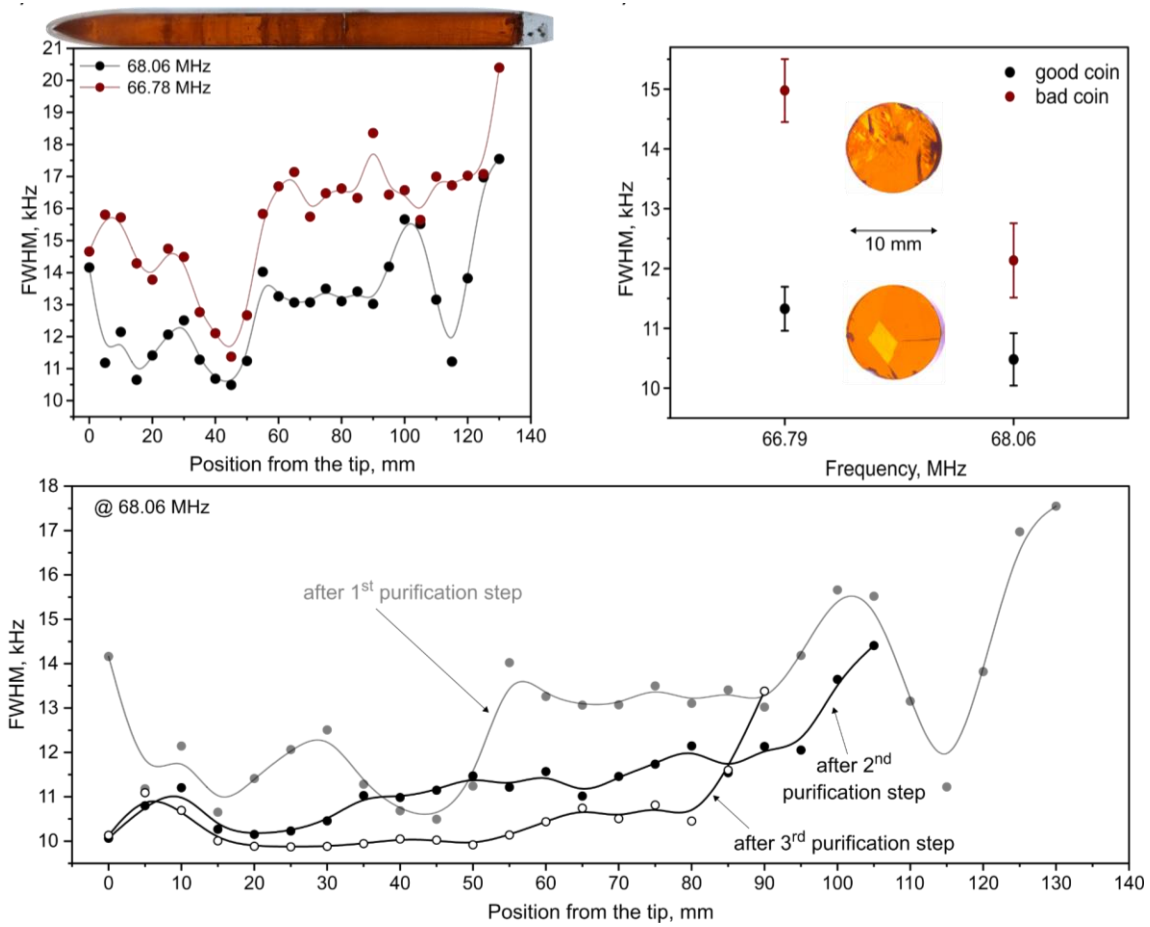
NMR & NQR

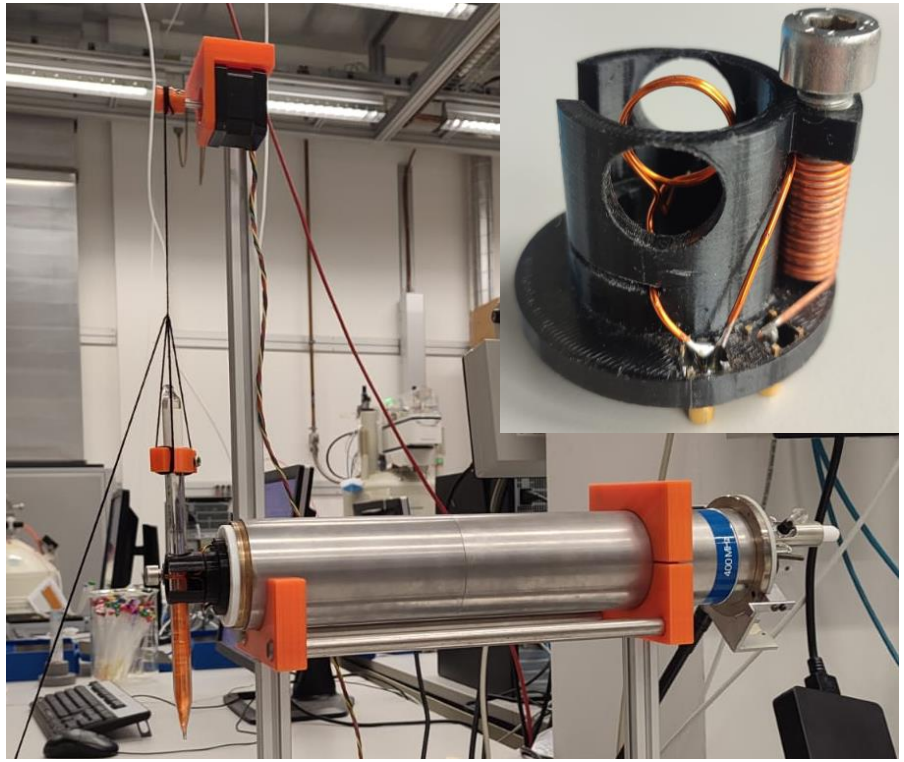




Currently two PhD-students (Lidiia and Sebastian) work on this topic and are happy to supervise students.
Currently we are looking to expand ☺

NQR: who needs magnets anyway? ☺





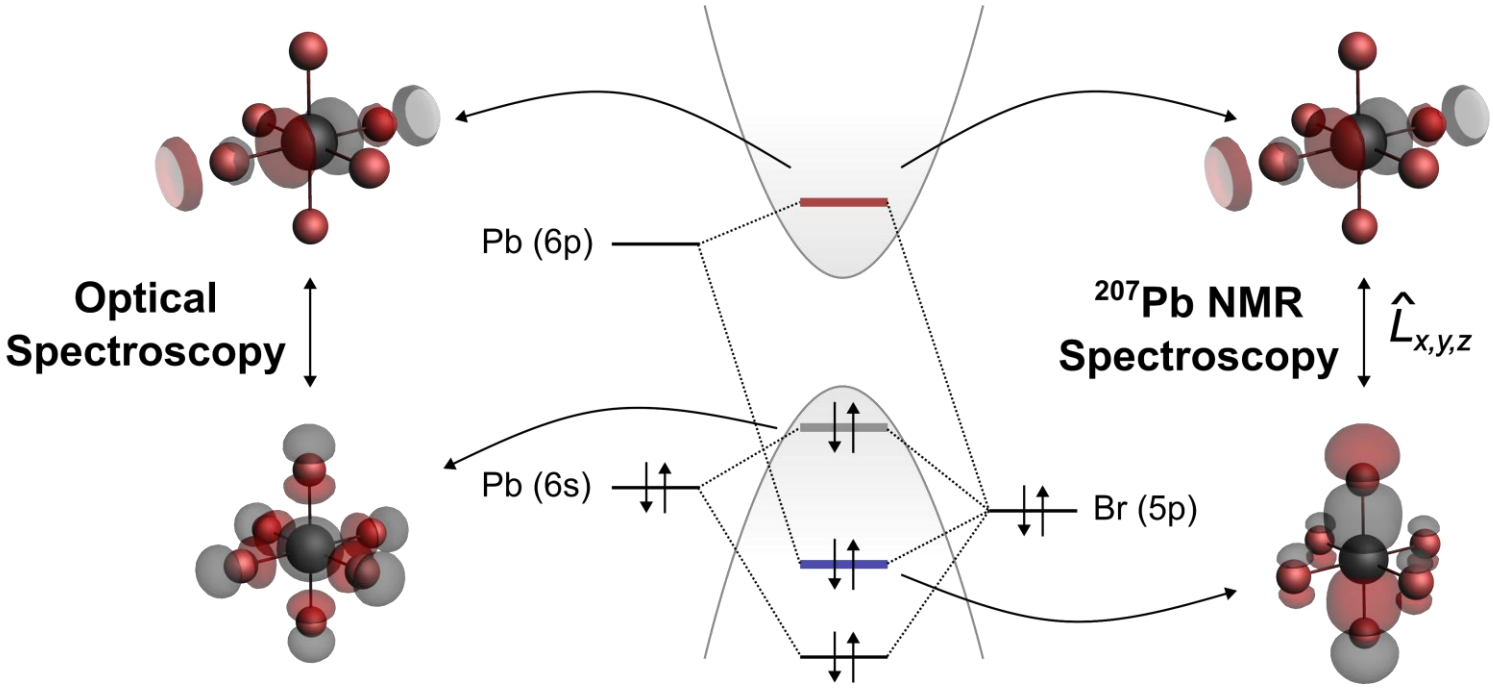
Our self-made setup

NQR can elucidate properties both:

- microscopic (local structure and dynamics)
- macroscopic (crystal orientation and defect density)

Flexible and widely interdisciplinary projects in materials chemistry, spectroscopy and engineering are possible!

NMR: Molecular-level insights into the next-gen Semiconductors



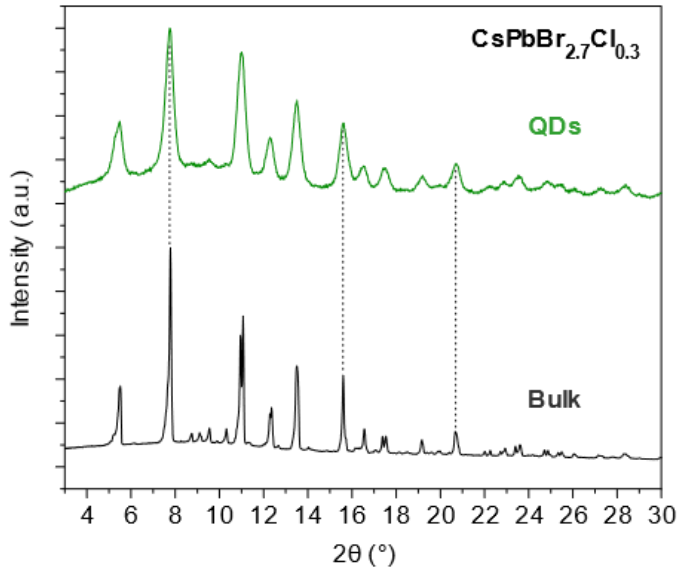
Many versatile project topics both for solid and solution state NMR ☺

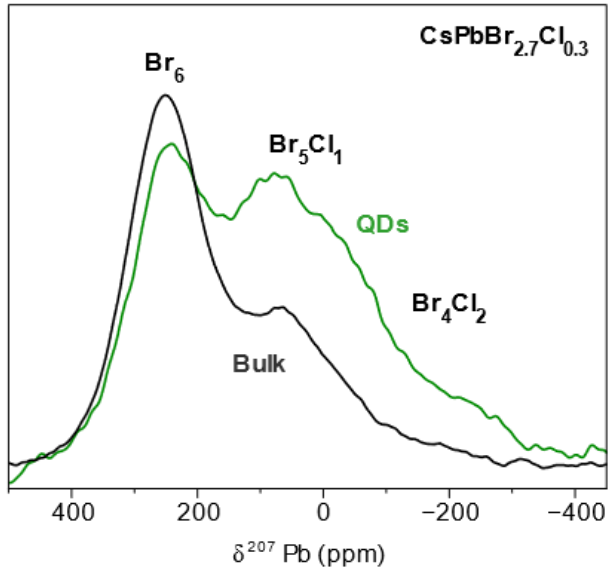
NMR Spectroscopy is very versatile and yields information about:

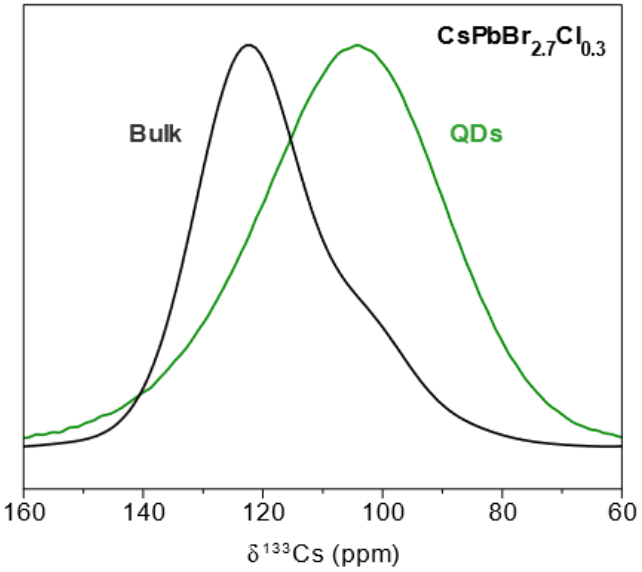
- Local Structure (local composition, bond angles, lattice expansion, …)
- Electronic Structure (quantum confinement, unusual temperature effects, …)
- Ligand Dynamics (Exchangeable ligands for photocatalysis, strongly bound ligands for single-photon spectroscopy)

…

NMR: Molecular-level insights into the next-gen Semiconductors







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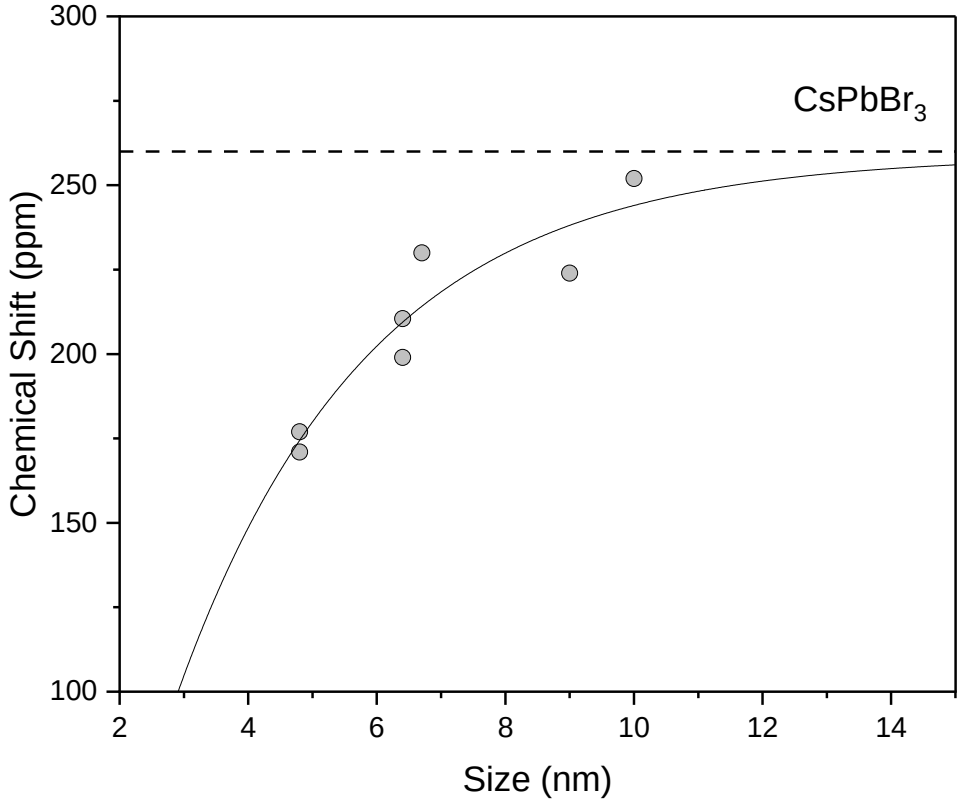

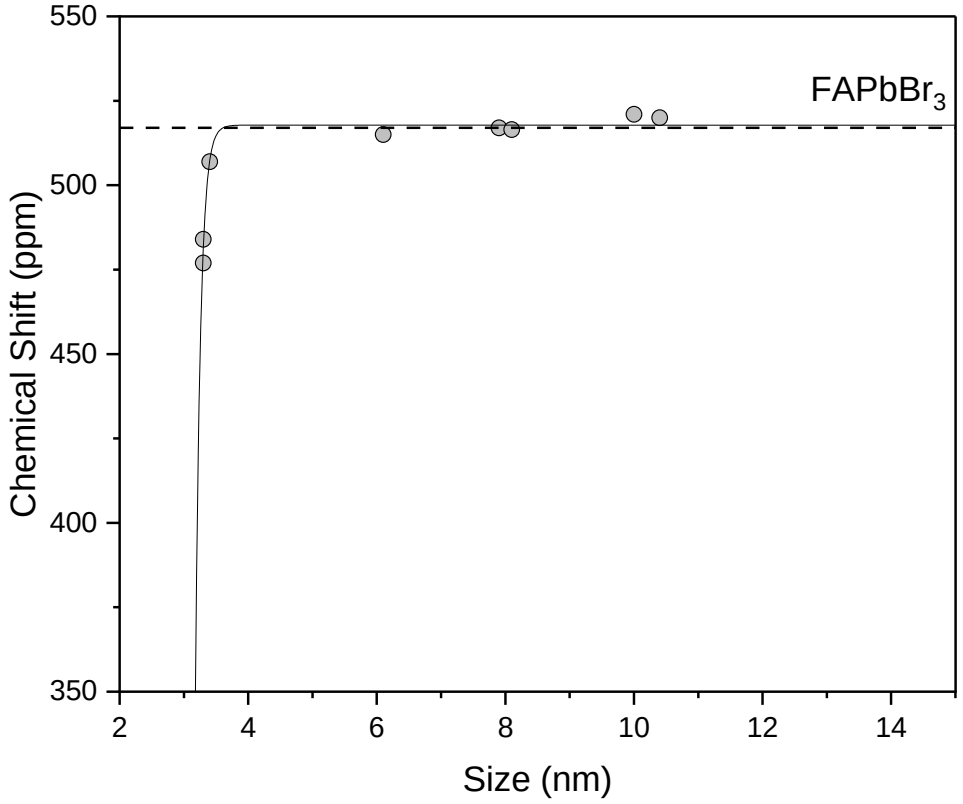

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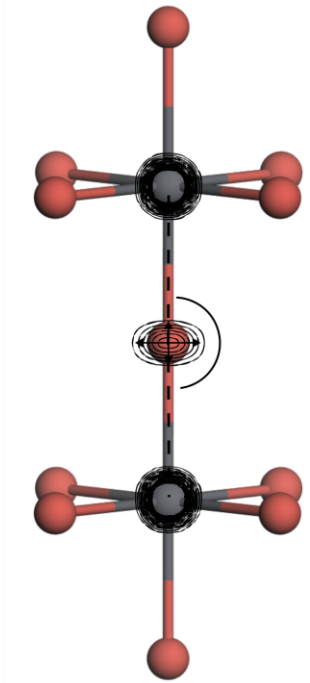
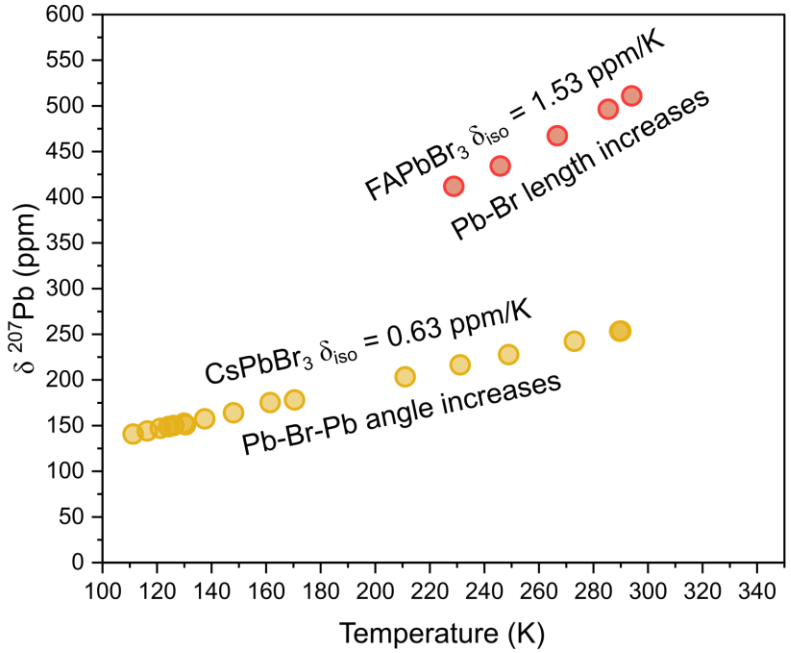
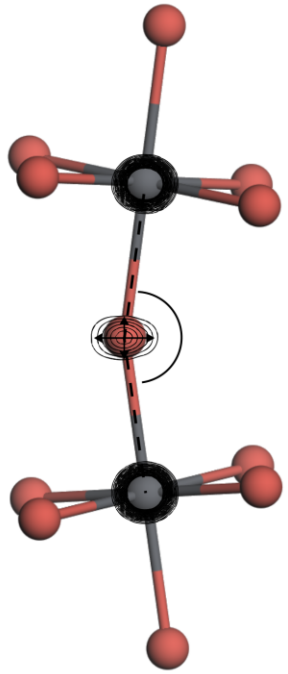


FAPbBr3
Cubic / Pm3m
E_G = 2.15 eV+ 0.5 meV/K





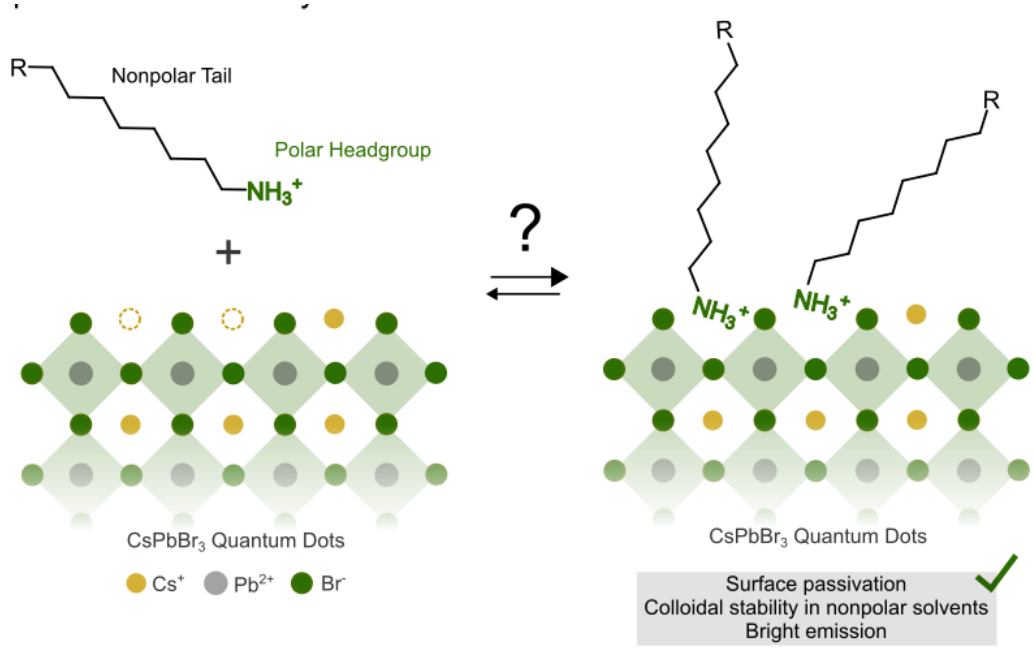
CsPbBr3
Orthorhombic / Pnma
E_G = 2.34 eV + 0.2 meV/K

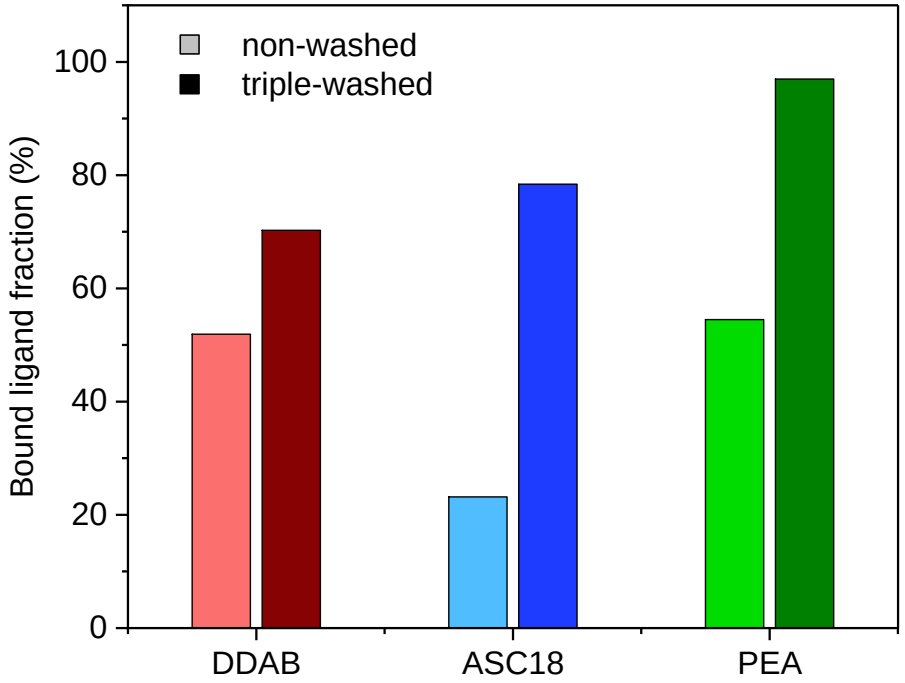
NMR Spectroscopy is very versatile and yields information about:

- **Local Structure** (local composition, bond angles, lattice expansion, …)
- **Electronic Structure** (quantum confinement, **unusual temperature effects**, …)
- Ligand Dynamics (Exchangeable ligands for photocatalysis, strongly bound ligands for single-photon spectroscopy)

…

NMR: Molecular-level insights into the next-gen Semiconductors





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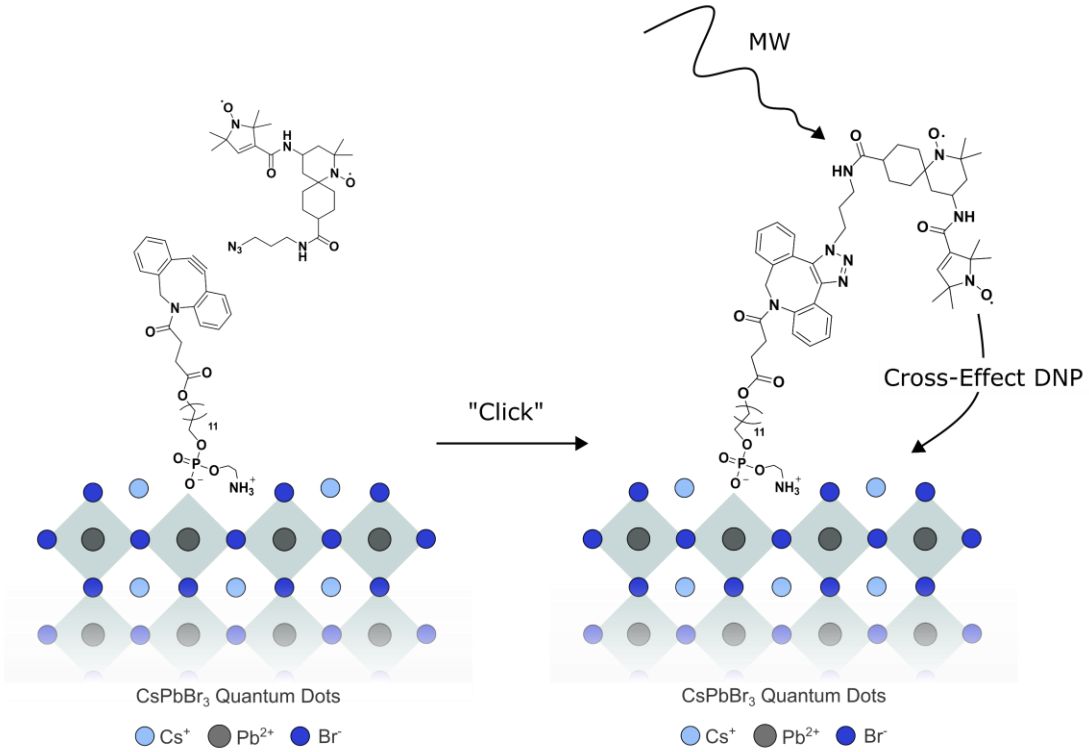
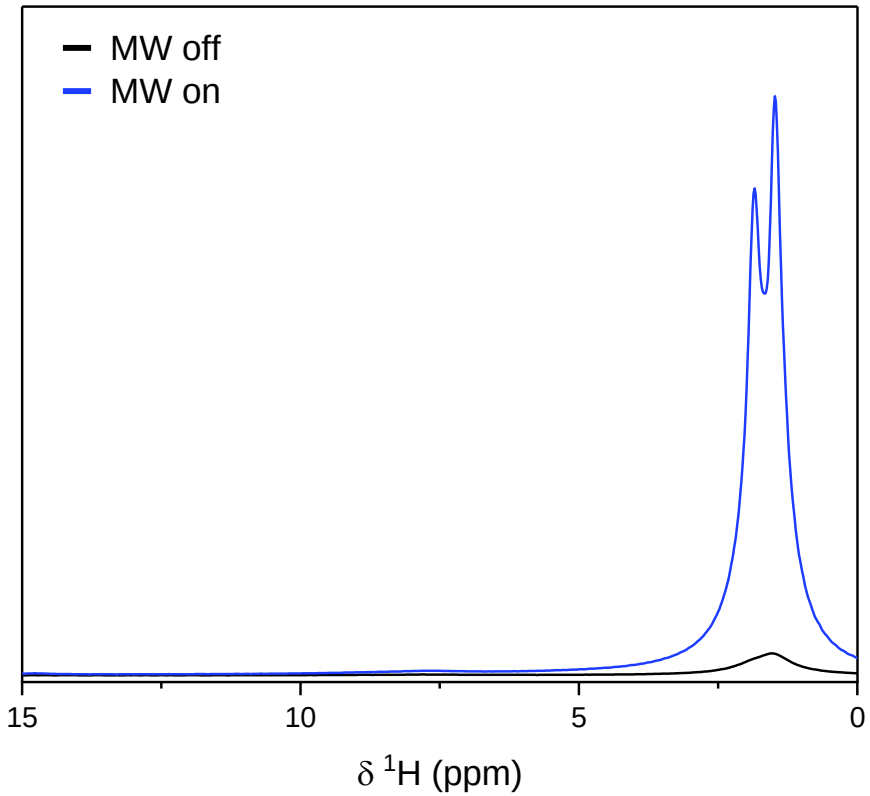




Or join us in designing new approaches to Dynamic Nuclear Polarization for quantum dots.

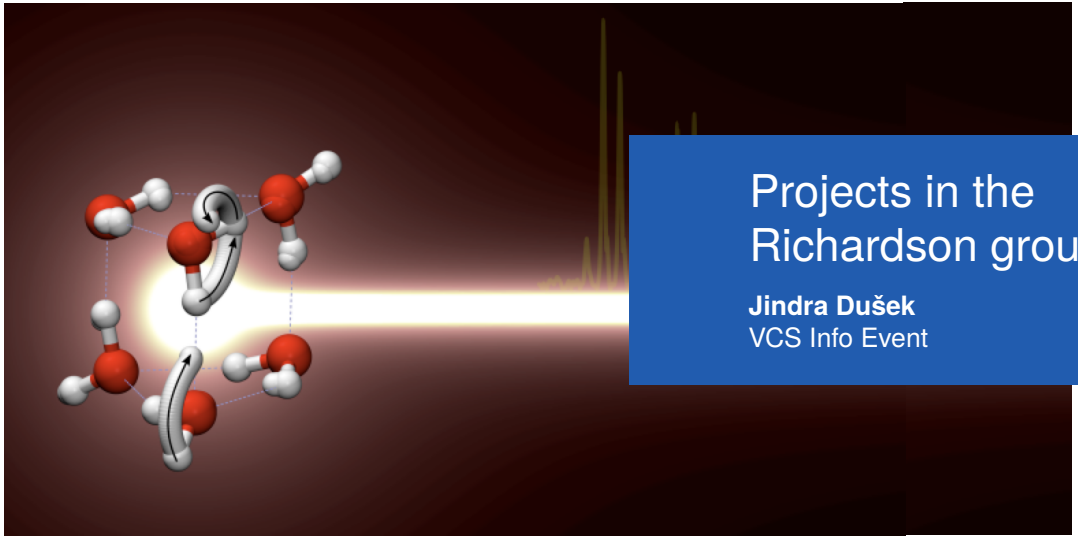
Your own ideas for projects are always welcome and no prior knowledge of NMR/NQR is required!
Just email us (sabischs@ethz.ch / ldubenska@ehtz.ch) or stop by in H121 for a coffee/chat.

What we offer you:

- Work under supervision of a junior and an experienced researcher
- Learn about nanomaterials characterizations
- Perform cutting-edge research in an interdisciplinary field
- Apply your perspective and original thinking to set new impulses in this growing field
- Freely choose what you focus on (chemistry/physics, experiment/theory/analysis, …)

If you want to learn more, get a tour or join us: mvkovalenko@ethz.ch

- baymoz@ethz.ch ,
- arajan@student.ethz.ch,
- sabischs@ethz.ch & ldubenska@ehtz.ch



Projects in the Richardson group

Jindra Dušek

VCS Info Event

Introduction

- Basic info:
  - www.richardson.ethz.ch
  - HCI D 267.3

Introduction

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- **Theoretical molecular quantum dynamics**

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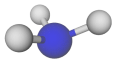
  - HCI D 267.3
- **Theoretical molecular quantum dynamics**
- Intersection between: physics, chemistry, math and informatics

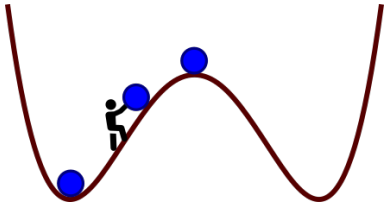
Quantum tunnelling

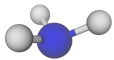


Quantum tunnelling

- Basic rate theory

$$k = A \exp\left(-E_a/RT\right) .$$





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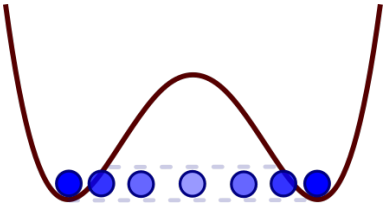

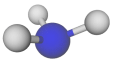

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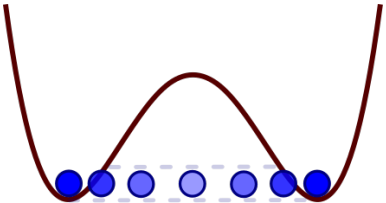
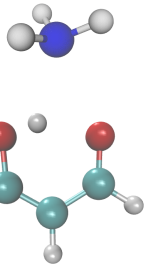
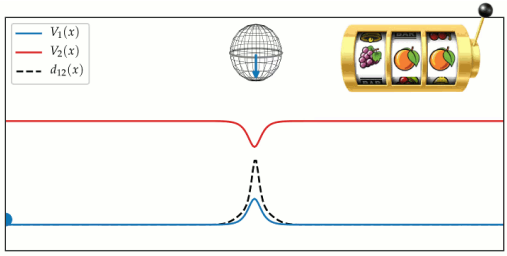
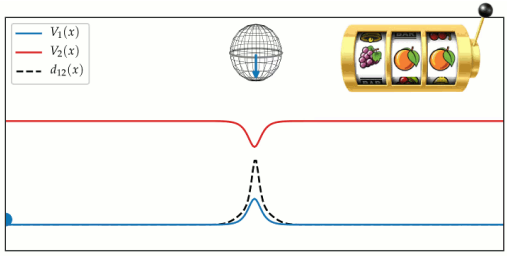


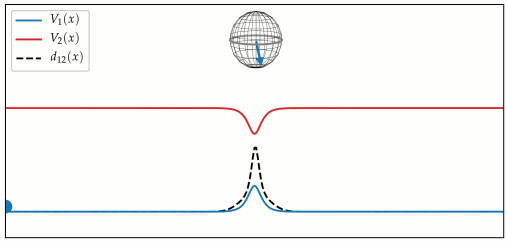


Nonadiabatic dynamics



Nonadiabatic dynamics





Topics

- Chemistry
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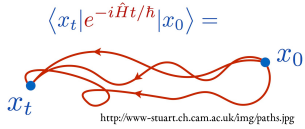

Topics

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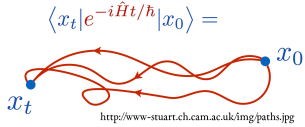
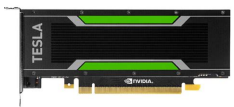
  - …
- Informatics
  - Python, Git
  - GPU computing
  - …





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  - Chemical problem (chemistry) -> Theory (math) -> Validation (computer simulations)
- In our group, you will join us in this process.
- No need to be a multi-disciplinary expert!
- You don’t have to be a math superstar

Get in touch

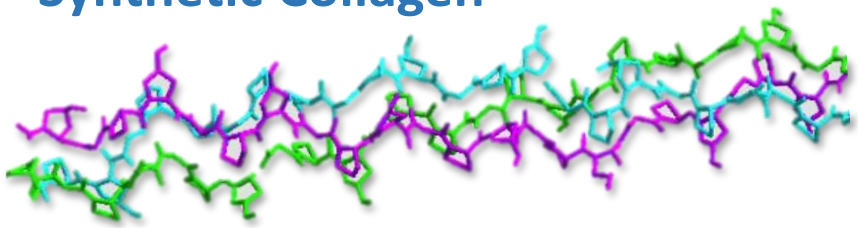
- Just come to our office at HCI D 267.3!
- https://www.richardson.ethz.ch/group/open-positions.html
- jindrich.dusek@phys.chem.ethz.ch
- rjeremy@ethz.ch

Peptides:
From Cell Penetration to Catalysis

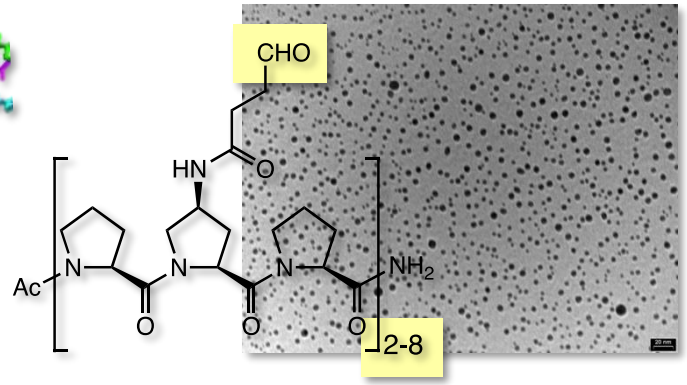
Lena Beiersdörfer - Semesterarbeitsinfoevent, 11.12.2024

Research in the Wennemers Group

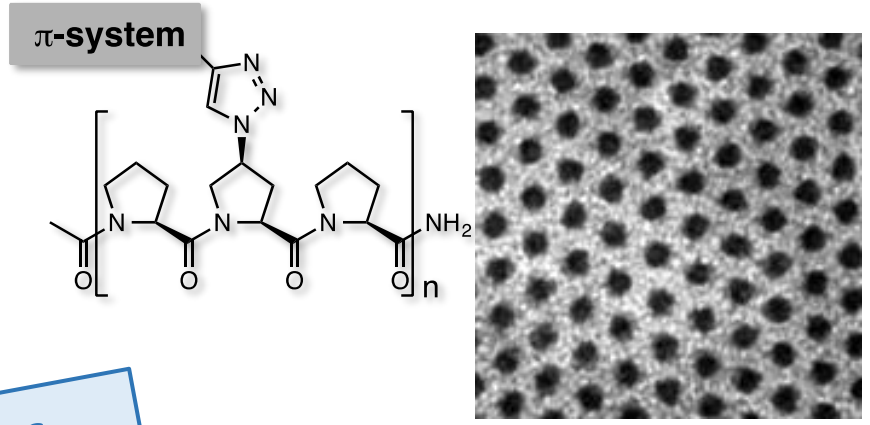
Synthetic Collagen



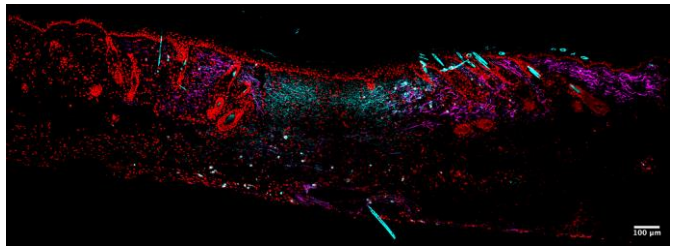
Metal Nanoparticles

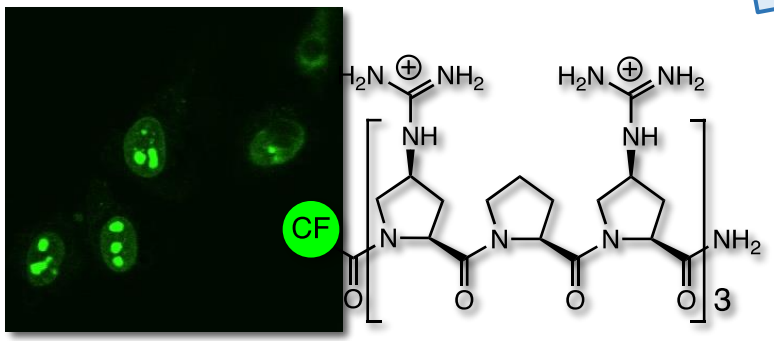


Supramolecular Assemblies



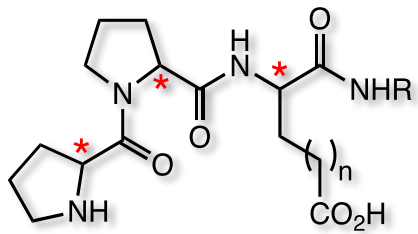
Chemical Biology



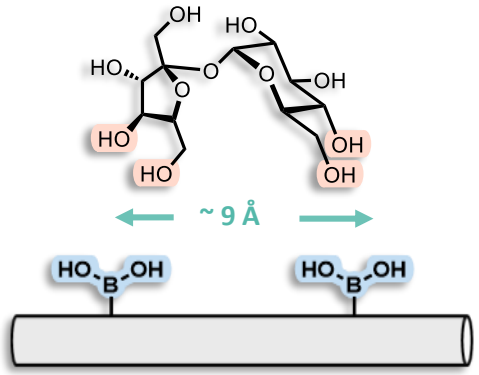


Peptides – Molecular Allrounders

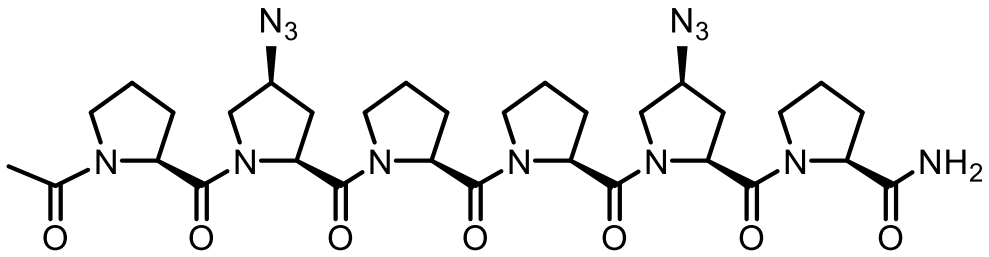
Asymmetric Catalysis



Host-guest Chemistry

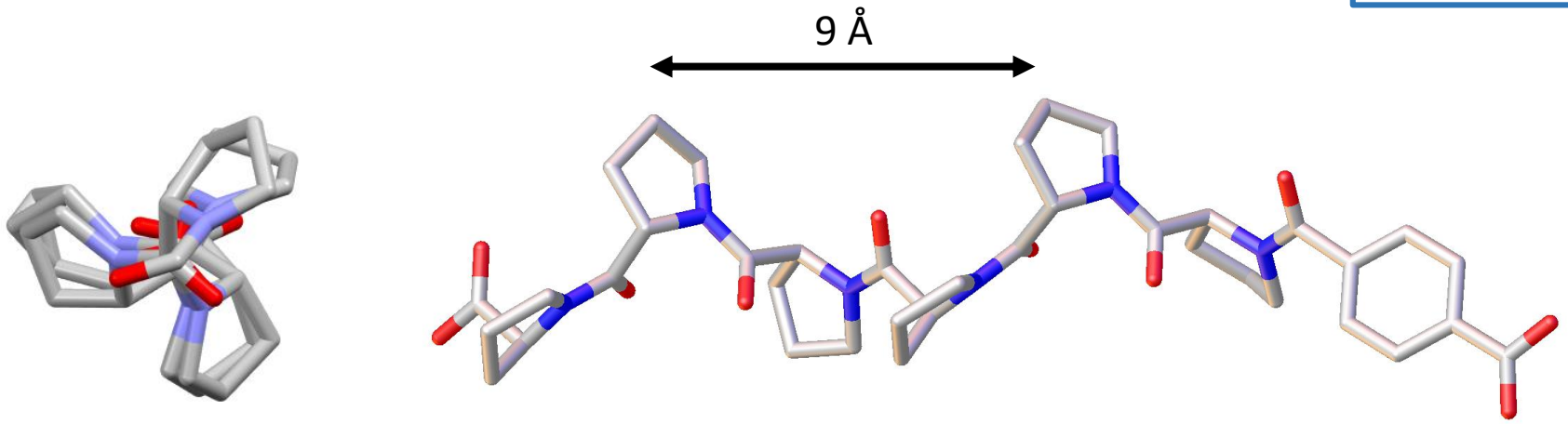


Oligoprolines – Versatile Molecular Scaffolds



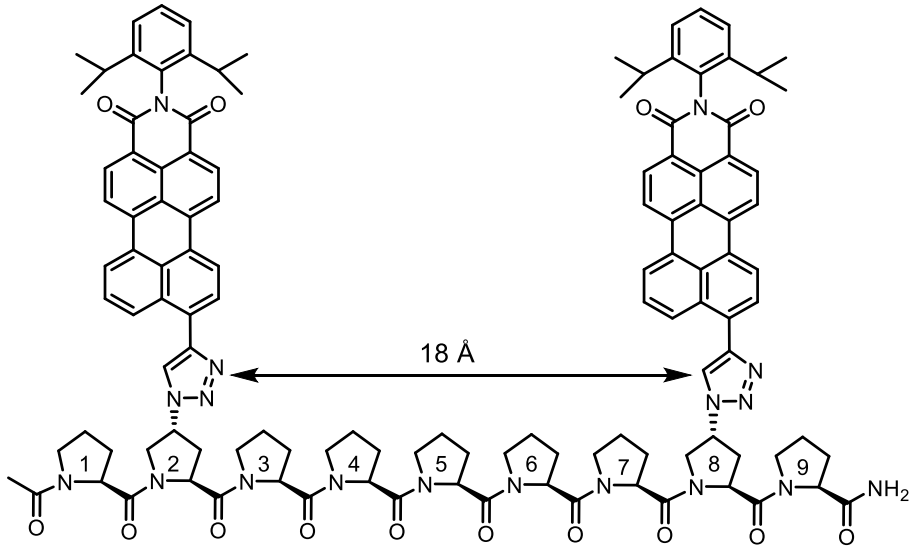
Polyproline II helix

- Three residues for one turn
- Distance of 9 Å
- Scaffold is functionalizable by incorporation of azidoproline



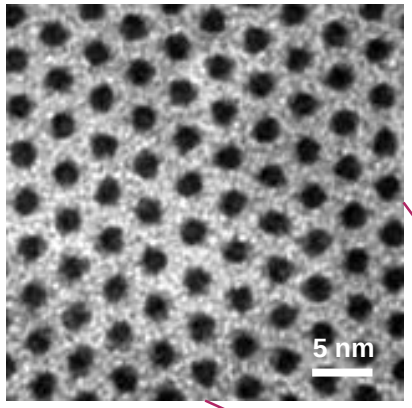
A triaxial supramolecular weave

- *Organic Synthesis*
- *Supramolecular Chemistry*
- *Cool Analytical Techniques*

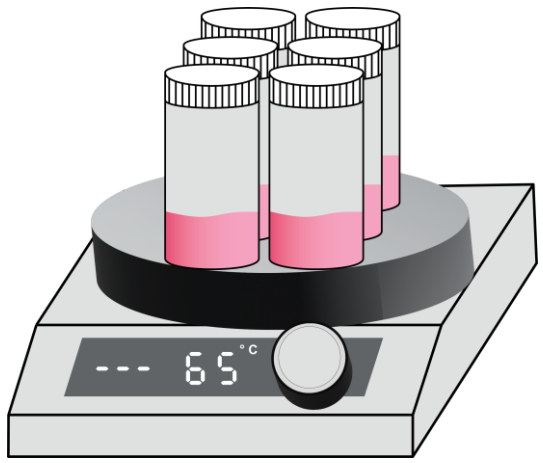


Possible projects

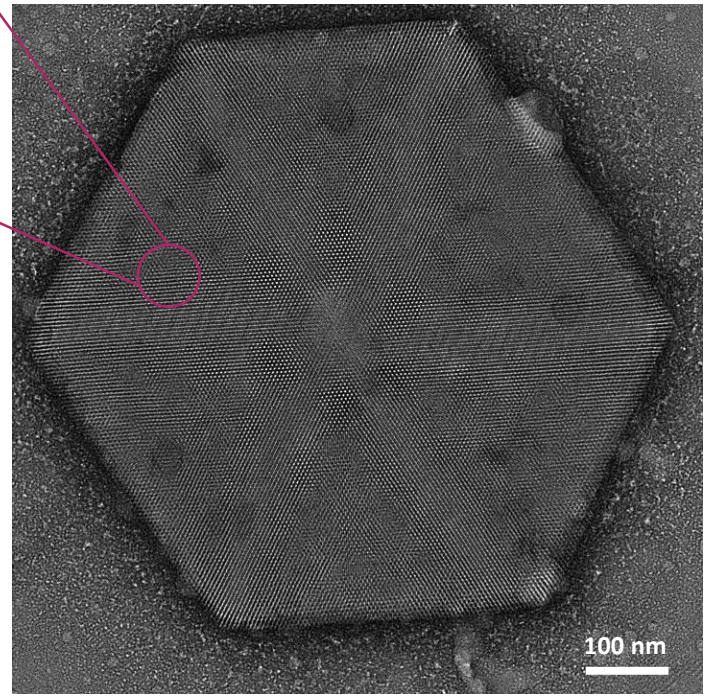
- Organic synthesis of building block (e.g. ^{13}C labelling for solid state NMR, derivatization of standard structure)
- TEM analysis of assemblies



Annealed 65°C, 1h,
3:7 THF/H_2O



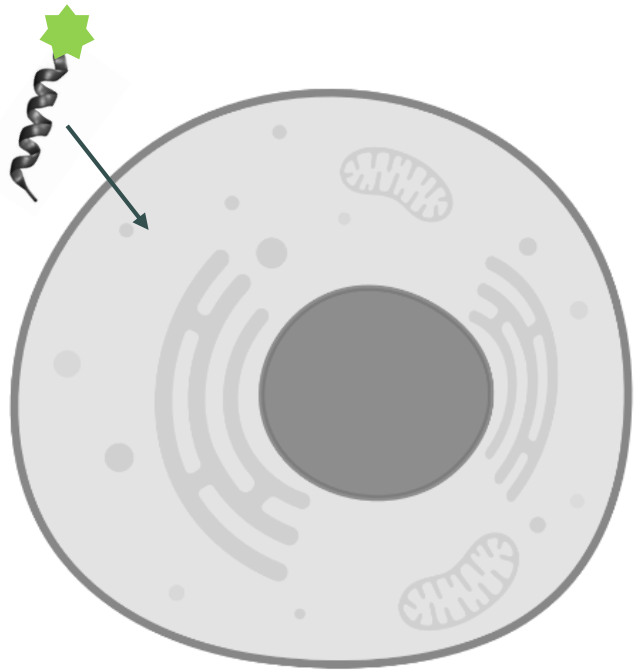
Transmission Electron Microscopy

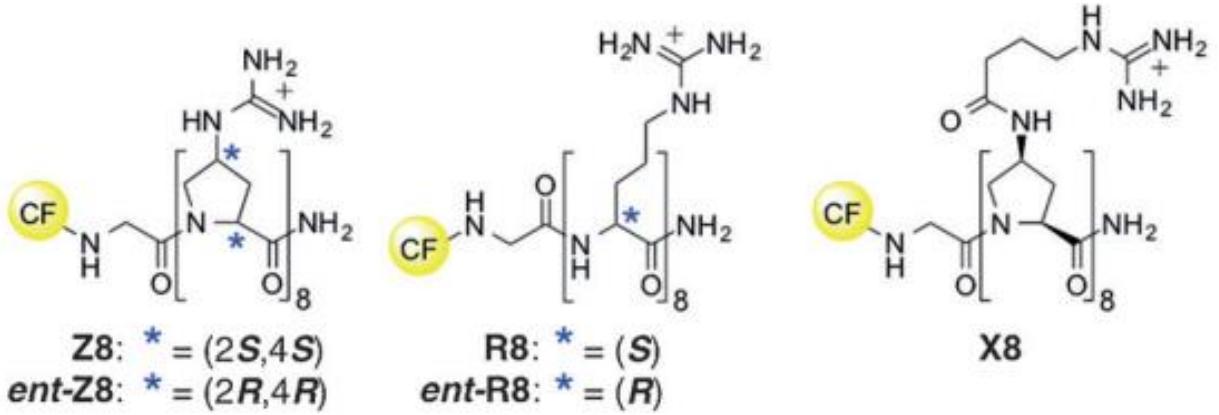


Kagome: 'basket with eyes'

U. Lewandowska *et al*, *Nature Chem,* 2017, **9**, 1068-1072
A. Herdlischka, PhD Thesis, ETH Zurich, 2022

Cell Penetrating Peptides

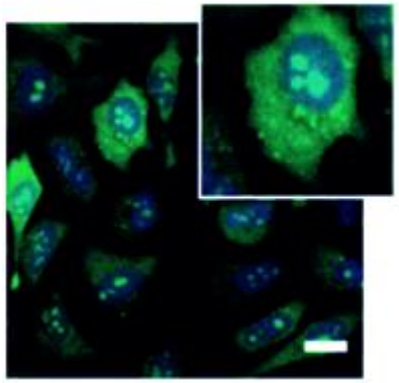




Projects

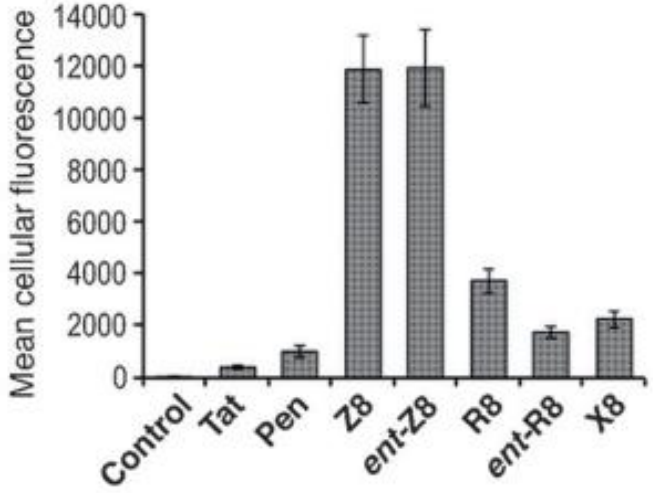
- Synthesis of new peptides by SPPS
- Analysis and characterization of the peptides
- Cell experiments and microscopy to determine localization in cells

Confocal



Hela, 10 µM Z8 for 1 h at 37 °C

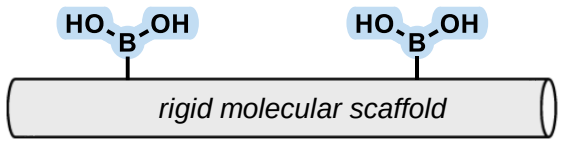
FACS

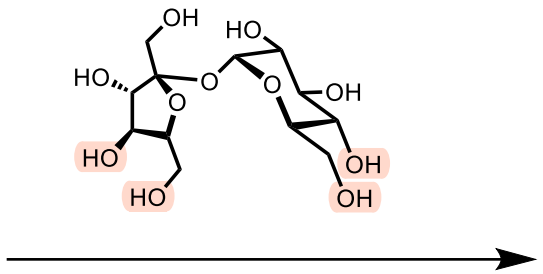


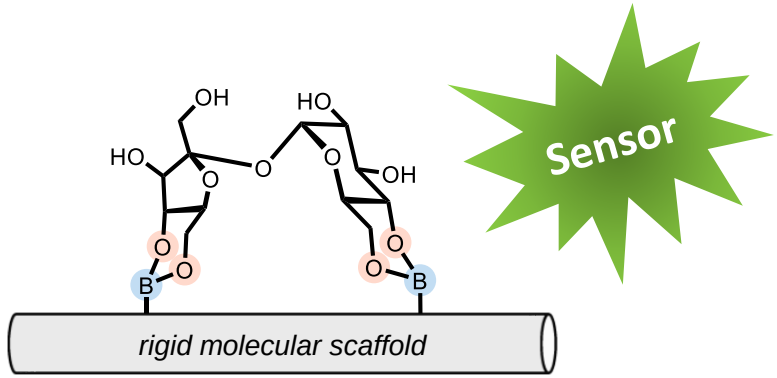
Hela, 10 µM for 1 h at 37°C

Y. A. Nagel, P. Raschle, H. Wennemers, *Angew. Chem.* **2017**, *129*, 128-132.

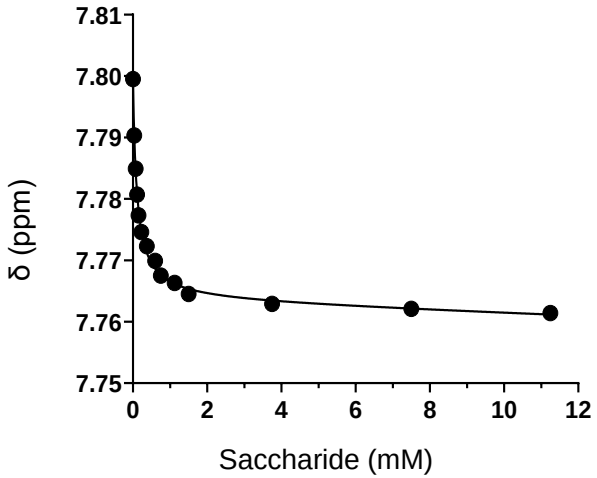
Synthetic Receptors for Carbohydrates

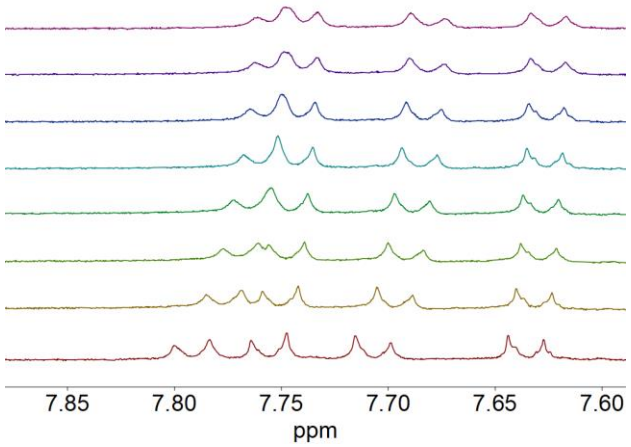






selective binding of saccharides



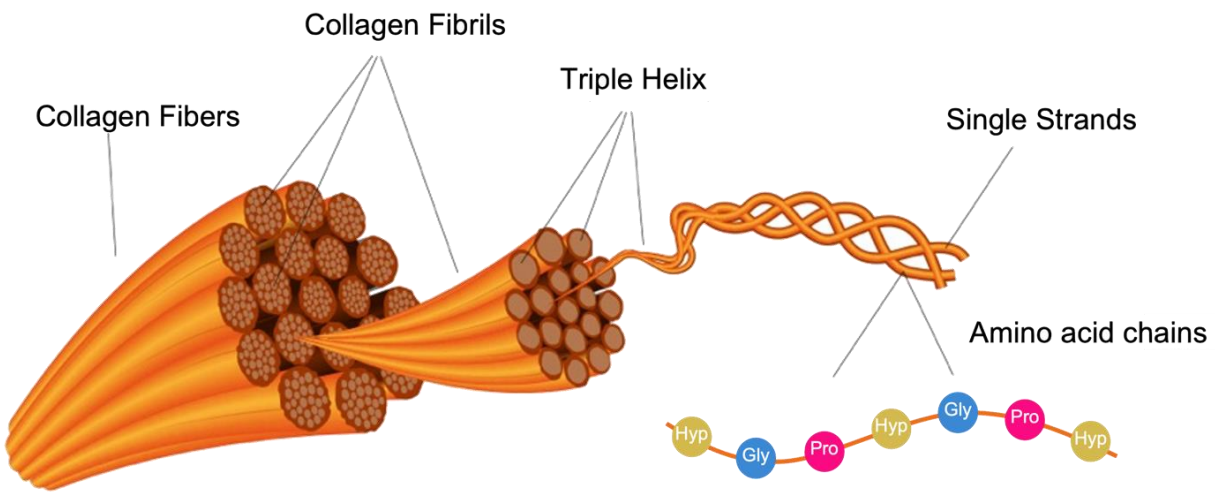


Projects

- Improvement of parent receptor
- Development of receptors for other saccharides
- Development of a sensor
- Organic synthesis, SPPS, characterization & analysis

D. Zetschok, PhD Thesis, ETH Zurich, 2022

Synthetic functionalized heterotrimeric collagen mimetic assemblies



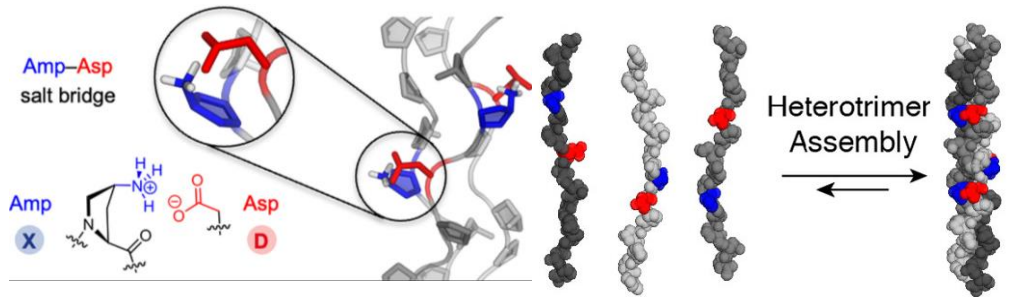
2

Going forward: Controlling the selective assembly of not only the triple helix, but also fibril formation!

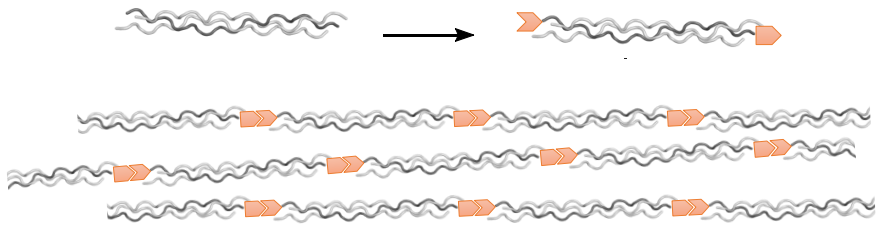
1

So far: Successfully created a "self-sorting" code for selective synthetic collagen heterotrimer assembly!

Our "sort-code"



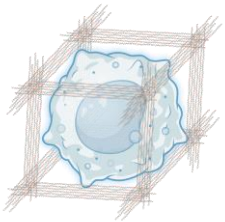
Ongoing project: incorporation of functional groups directing fibril propagation



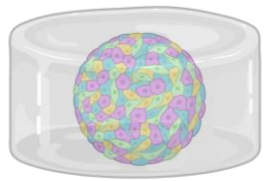
3

Ultimate challenge: Functionalized synthetic hetrotrimeric collagen fibrils

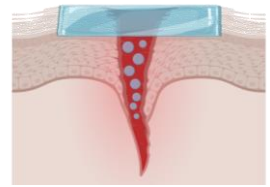
Incorporation of collagen functional sequences and testing recognition events in the presence of cells as a step towards development of wound-healing materials, 3D cell culture and others!



Cell encapsultion



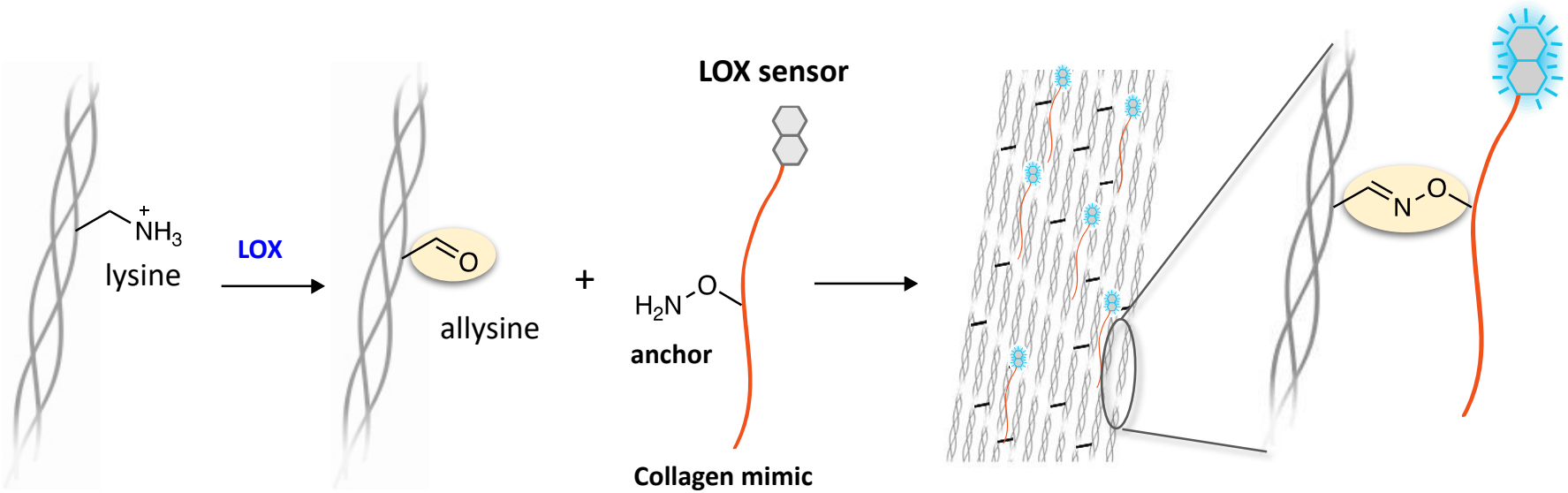
3D cell culture

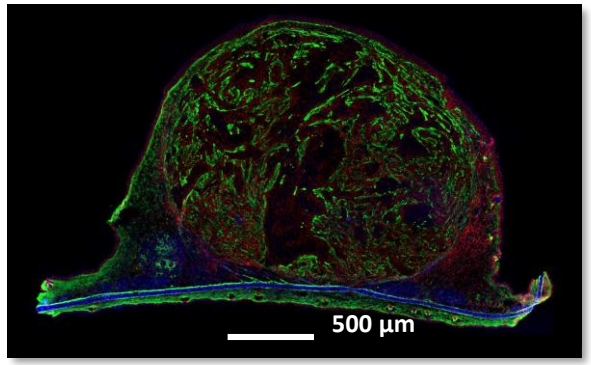


Wound healing patches

Encyclopedia of Polymeric Nanomaterials. **2013**, Springer, Berlin, Heidelberg; Wennemers, *J. Am. Chem. Soc.*, **2020**, *142*, 2208-2212, *Wennemers, J. Am. Chem. Soc.* **2024**, *146*, 1789- 1793.

Monitoring and visualizing LOX activity

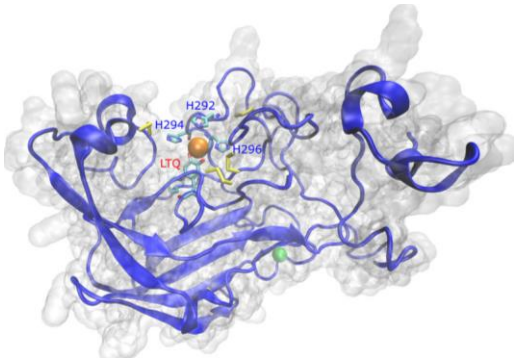




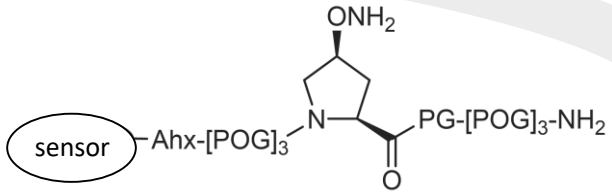
Projects

- Organic synthesis of new probes and dyes
- Investigation of new compounds for targeting proteins or as small molecule drugs against fibrosis
- Investigation of new fluorophores as sensors

LOX inhibitor/selectivity



Targeting moiety



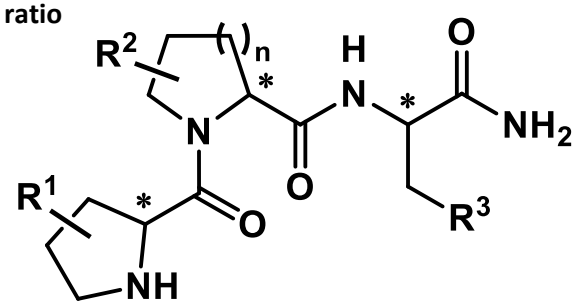
Diagnostic & therapeutic tools

under development

M. Aronoff, P. Hiebert, N. B. Hentzen, S. Werner, H. Wennemers, *Nat. Chem. Biol.*, **2021**, *17*, 865.

Asymmetric Organocatalysis with Peptides – the Pro-Pro-Xaa motif

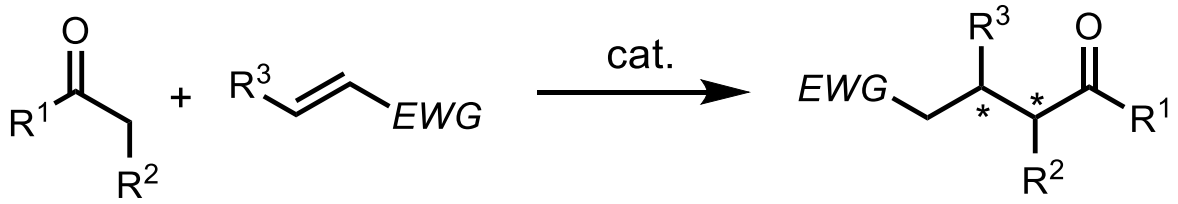
2nd amino acid
trans/cis ratio



3rd amino acid
Important for b-turn side chain for substrate coordination

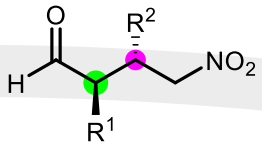
1st amino acid: Proline
reactive site: 2nd amine

Reactions catalyzed by Pro-Pro-Xaa catalysts:



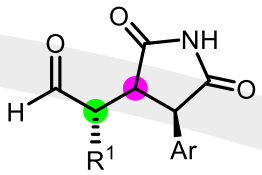
a) M. Wiesner, J. D. Revell, H. Wennemers, *Angew. Chem. Int. Ed.* **2008**, 120, 1897; **b) J.** Duschmalé, H. Wennemers, *Chem. Eur. J.* **2012**, 18, 1111; **c)** R. Kastl, H. Wennemers, *Angew. Chem. Int. Ed.* **2013**, 52, 7228; **d) T.** Schnitzer, H. Wennemers, *Synlett* **2017**, 28, 1282; **e) T.** Schnitzer, A, Budinská, H. Wennemers, *Nat. Catal.* **2020**, 3, 143; **f)** J. S. Moehler, T. Schnitzer, H. Wennemers, *Chem. Eur. J.* **2020**, 26, 15623; **g)** C. E. Grünenfelder, J. K. Kisunzu, H. Wennemers, *Angew. Chem. Int. Ed.* **2016**, 55, 8571; **h)** G. Vastakaite, C. E. Grünenfelder, H. Wennemers, *Chem. Eur. J.* **2022**, 28, e202200215; **i)** T. Schnitzer, J.W. Rackl, H. Wennemers, *Chem. Sci.,* **2022**, *13*, 8963-8967. **j)** M. Schnurr, J. W. Rackl, H. Wennemers, *J. Am. Chem. Soc.* **2023***, 145,* 23275–23280.; **k)** A. Budinská A., H. Wennemers, *Angew. Chem. Int. Ed.* **2023**, *62*, e202300537.

H-Pro-Pro-Xaa Peptidic Catalysts –Applications



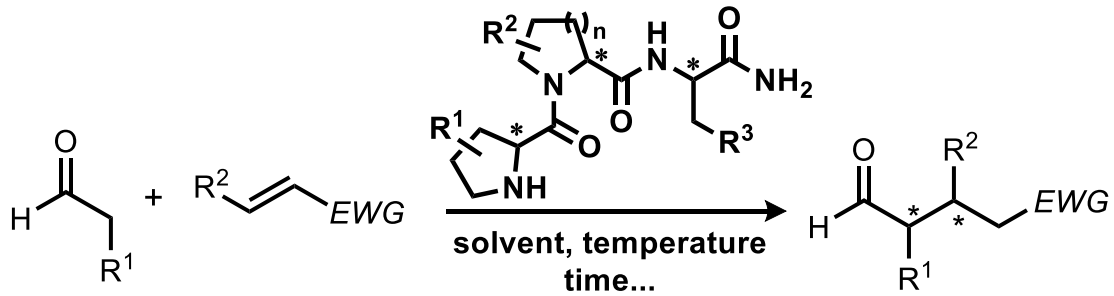
T. Schnitzer *et. al.*,
Nat. Catal. **2023**

up to 98% yield
up to >20:1 *d.r.*
up to 98% *ee*



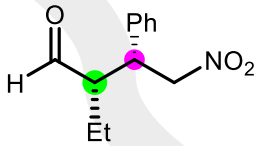
G. Vastakaite *et. al.*,
CEJ **2022**

up to 99% yield
up to >86:9:1:4 *d.r.*
up to 95% *ee*



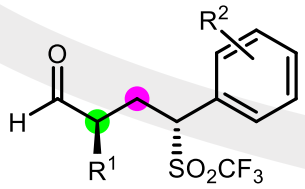
solvent, temperature
time...

reaction in complex environments



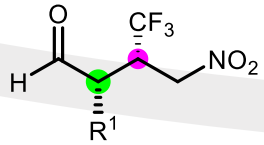
J. Rackl *et. al.*,
Chem. Sci. **2023**

Complex environments: Whiskey, Coke, Honey, Limmat water, fruit juice, cell lysate etc.
all > 95% *ee*



A. Budinská *et. al.*,
ACIE **2023**

56%-99% yield
3:1 to 13:1 *d.r.*
81-99% *ee*



M. Schnurr *et. al.*,
JACS **2023**

up to 99% yield
up to >20:1 *d.r.*
up to 99% *ee*

Projects

- Organic synthesis of starting materials
- Exploring new substrates and reactions for catalytic asymmetric transformations
- Optimization of catalyst and conditions
- Development of substrate scope

a) M. Wiesner, J. D. Revell, H. Wennemers, *Angew. Chem. Int. Ed.* **2008**, 120, 1897; **b) J.** Duschmalé, H. Wennemers, *Chem. Eur. J.* **2012**, 18, 1111; **c)** R. Kastl, H. Wennemers, *Angew. Chem. Int. Ed.* **2013**, 52, 7228; **d) T.** Schnitzer, H. Wennemers, *Synlett* **2017**, 28, 1282; **e) T.** Schnitzer, A, Budinská, H. Wennemers, *Nat. Catal.* **2020**, 3, 143; **f)** J. S. Moehler, T. Schnitzer, H. Wennemers, *Chem. Eur. J.* **2020**, 26, 15623; **g)** C. E. Grünenfelder, J. K. Kisunzu, H. Wennemers, *Angew. Chem. Int. Ed.* **2016**, 55, 8571; **h)** G. Vastakaite, C. E. Grünenfelder, H. Wennemers, *Chem. Eur. J.* **2022**, 28, e202200215; **i)** T. Schnitzer, J.W. Rackl, H. Wennemers, *Chem. Sci.*, **2022**, *13*, 8963-8967. **j)** M. Schnurr, J. W. Rackl, H. Wennemers, *J. Am. Chem. Soc.* **2023**, *145,* 23275–23280.; **k)** A. Budinská A., H. Wennemers, *Angew. Chem. Int. Ed.* **2023**, *62*, e202300537.

Questions?

PSI Center for Nuclear Engineering and Sciences | ETH zürich

The Laboratory of Radiochemistry @ PSI

@ ETHZ: Steinegger group

Georg Tiebel
VCS Research Group Introduction, 11 December 2024

The Laboratory of Radiochemistry at PSI

ETH zürich PSI

Postdoctoral researchers

PhD students

Prof. Dr. Robert Eichler

u b UNIVERSITÄT BERN

Sandha Keller (Admin, 80%)

ETH zürich

HEAVY ELEMENTS

Prof. Dr. Patrick Steinegger (DL)

Dr. Rugard Dressler
Alexander Vögele
Dominik Herrmann

Jennifer Wilson (SNF)
Georg Tiebel (SNF)
Paul Dutheil (ENSI, LOG)
Michael Hofstetter (BABS)

ISOTOPE & TARGET CHEMISTRY

Dr. Zeynep Talip

Dr. Jörg Neuhausen
Dr. Emilio Maugeri
Colin Hillhouse (ITM)
Dr. Djordje Cvjetinovic
Dr. Jelena Petrovic

Ivan Zivadinovic (EU, PATRICIA)
Noemi Cerboni (PSI)
Vladislav Zobnin (EU, PASCAL)
Xuandong Kou (Uni Bern)
Elizaveta Artiushova (Swissnuclear)
Sofia Pasolini (Swissnuclear)

RADIONUCLIDE DEVELOPMENT

Dr. Nick van der Meulen

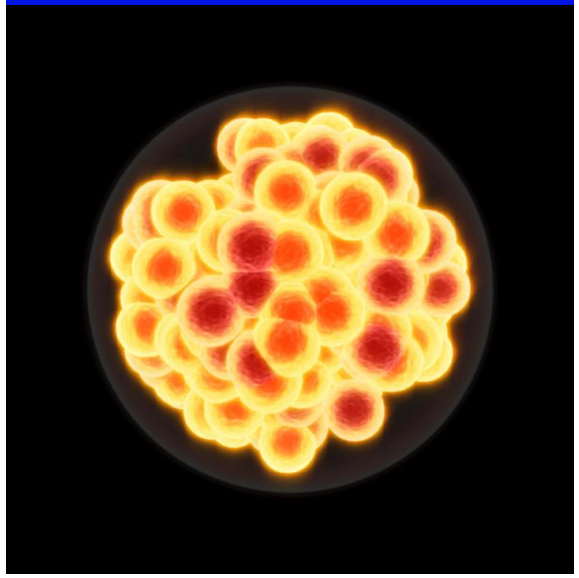
Dr. Anzhelika Moiseeva (CRS, BIO)
Dr. Pascal Grundler (CRS, BIO)
Dr. Maryam Mostamand

Edoardo Renaldin (Uni Bern)

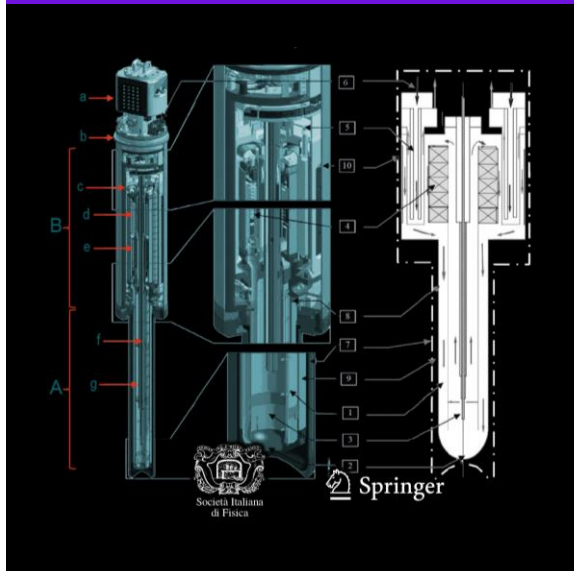
+ 2 to 3 Master- / Bachelor- / semester students

The Laboratory of Radiochemistry at PSI

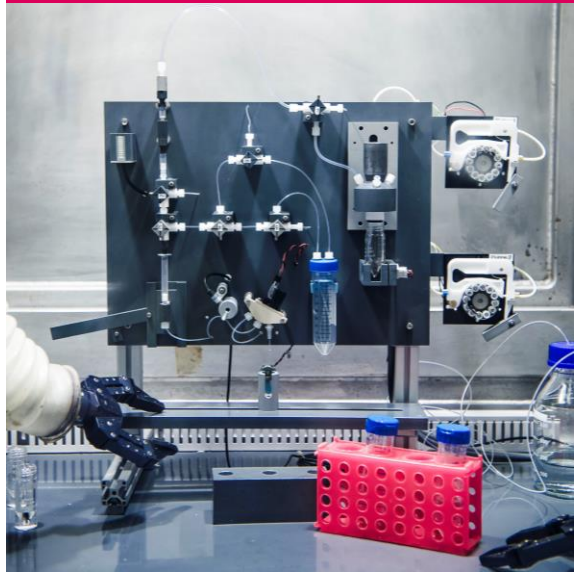
Heavy Elements



Isotope and Target Chemistry



Radionuclide Development



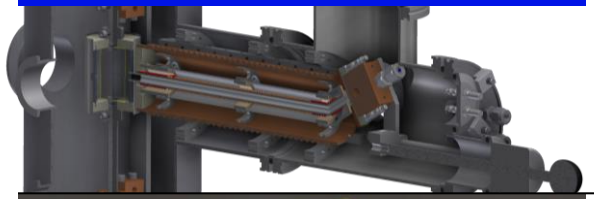
Pictures from: https://www.llnl.gov/; title page of the *European Physical Journal Plus* (vol. 131, no. 7, 2016) with a picture showing the MEGAPIE-target

The Laboratory of Radiochemistry at PSI

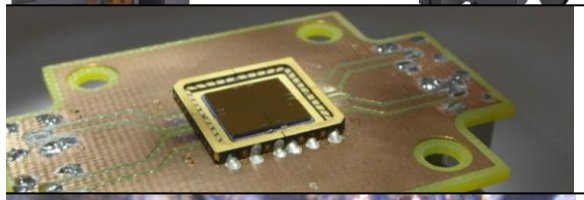
Heavy Elements

Isotope and Target Chemistry

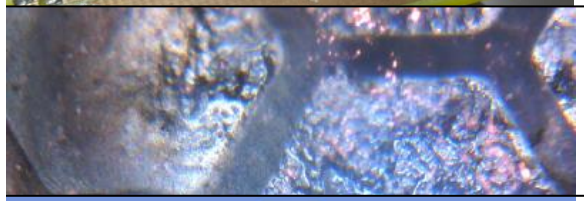
Radionuclide Development



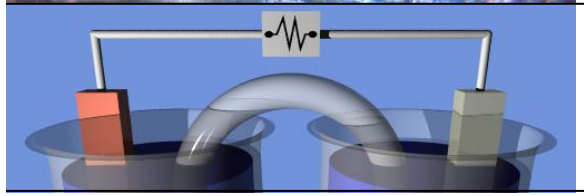
Gas adsorption chromatography with transactinide elements



Detector development for extreme conditions



Targets for heavy ion beam irradiations



Electrochemistry with transactinide elements

Daniell cell adapted from http://en.wikipedia.org

The Laboratory of Radiochemistry at PSI

Heavy Elements

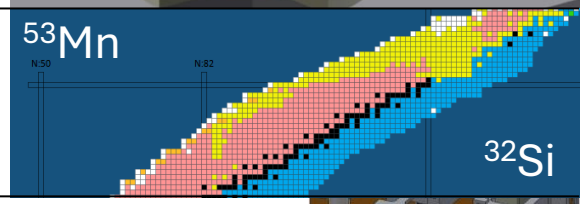
Isotope and Target Chemistry

Radionuclide Development

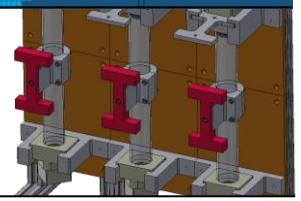
Liquid metal chemistry

Isotope extraction & target manufacturing

Improvement of nuclear physics data



Waste treatment & isotope reclamation



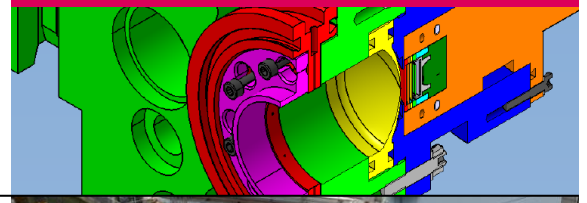
The Laboratory of Radiochemistry at PSI

Heavy Elements

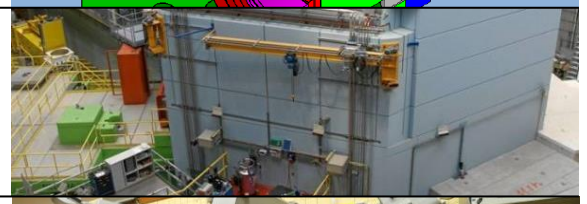
Isotope and Target Chemistry

Radionuclide Development

LRC + CRS

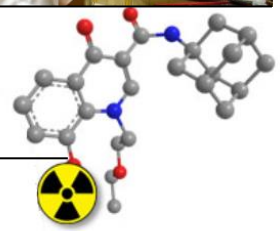


Target Development



Production of new radionuclides

Chemical separation and processing

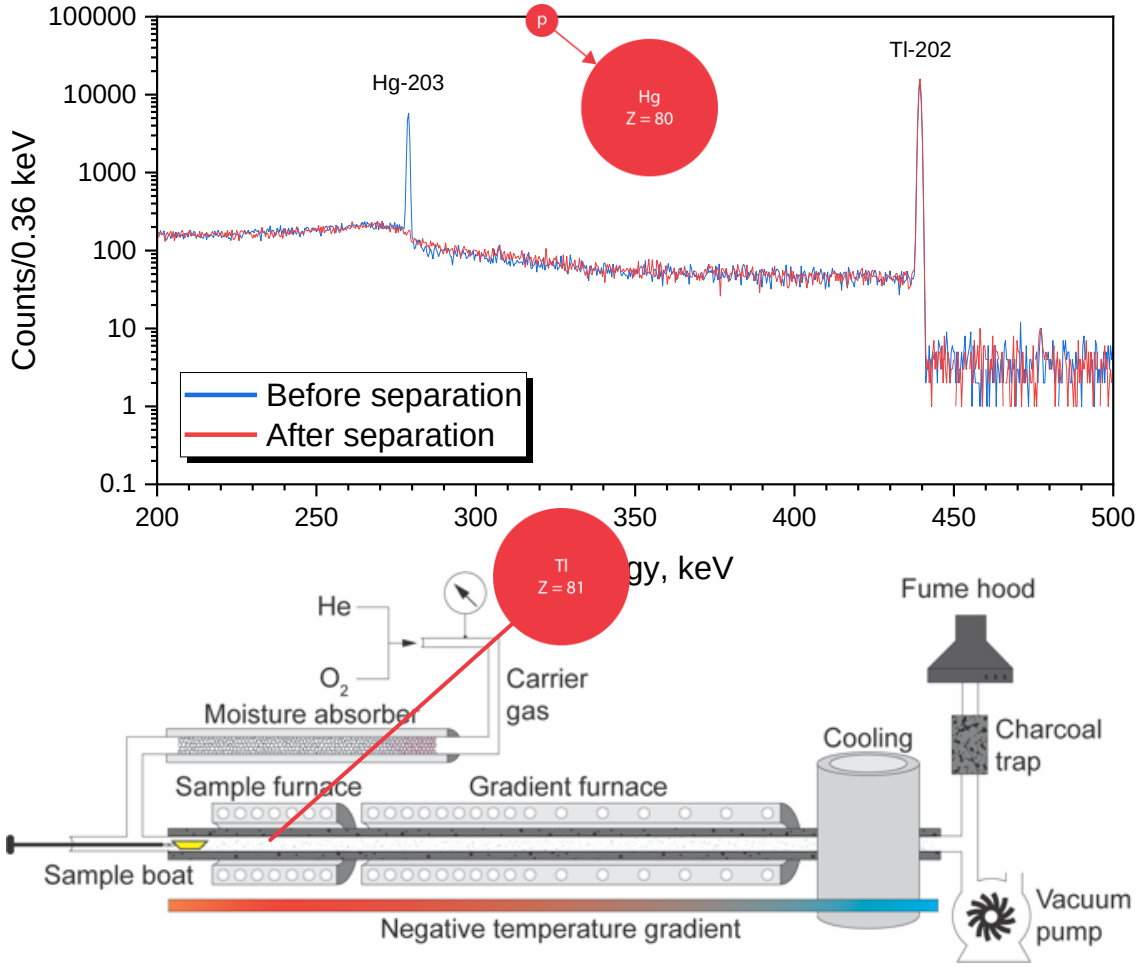


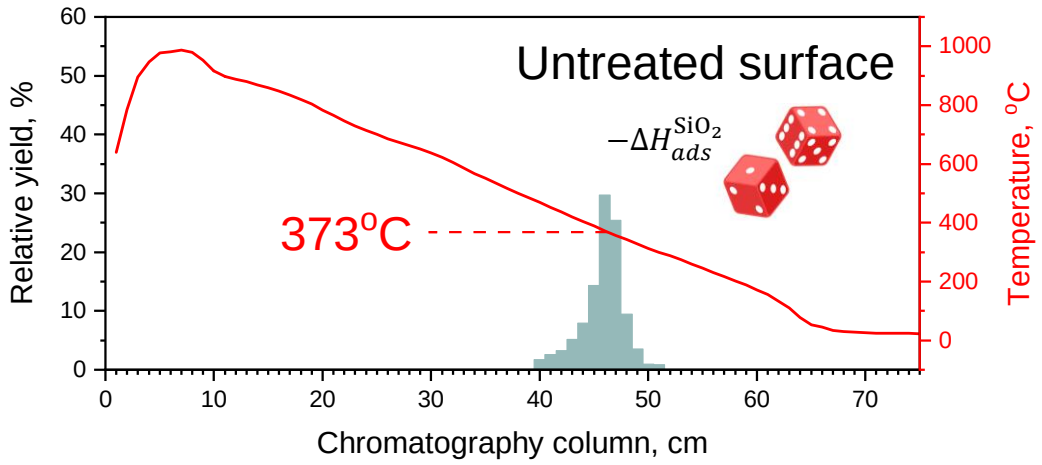
Theragnostics

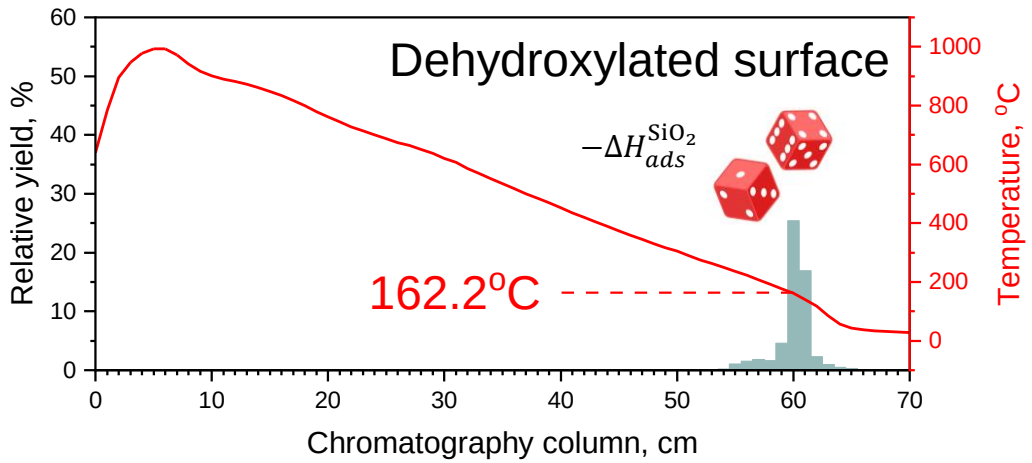
Project examples

Heavy Elements

Example **Gaschromatography studies with Tl on fused silica** (final project upon discussion)







Isotope and Target Chemistry

Targets

Cross section measurements

Nuclear Structure

Synthesis of SHEs

Sources

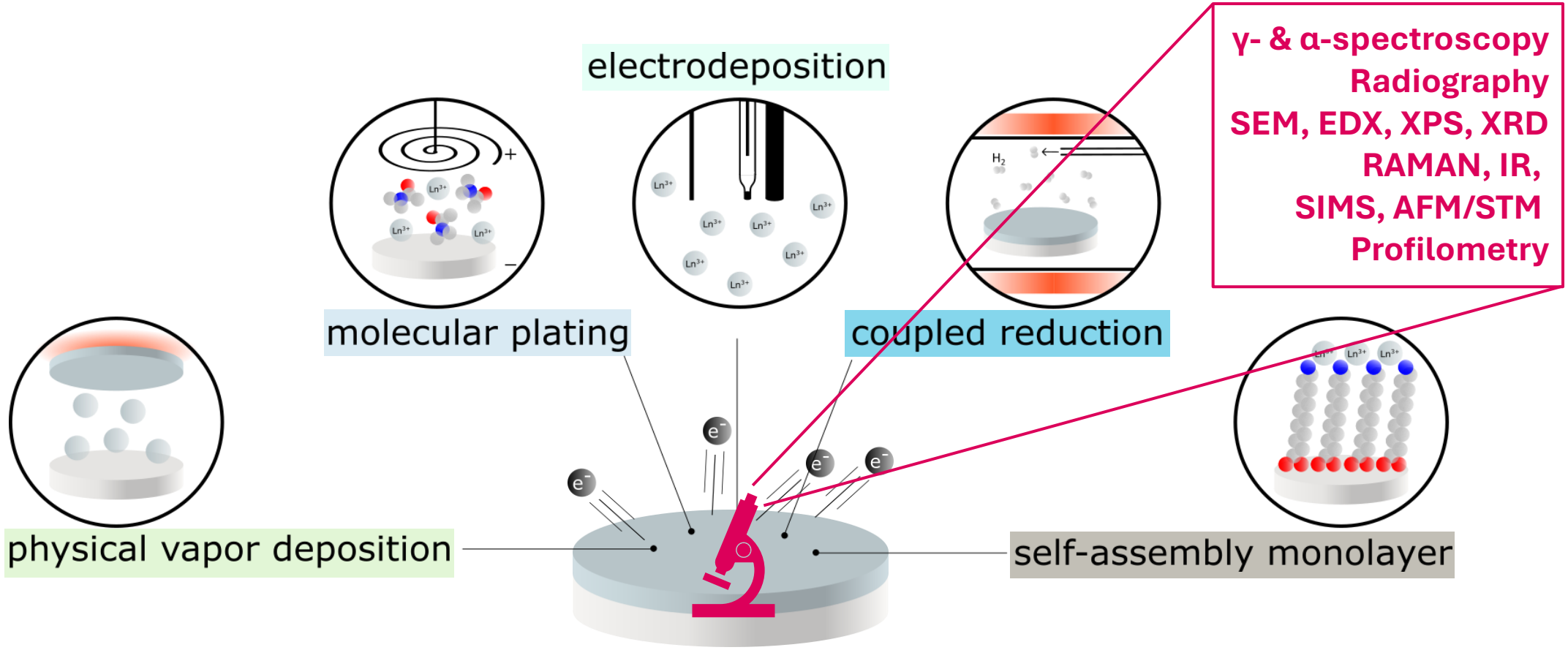
Calibration Standards

Nuclear Data Measurements

Interaction of radiation with matter

Isotope and Target Chemistry

Example **Uniform and radioactive thin films** (final project upon discussion)



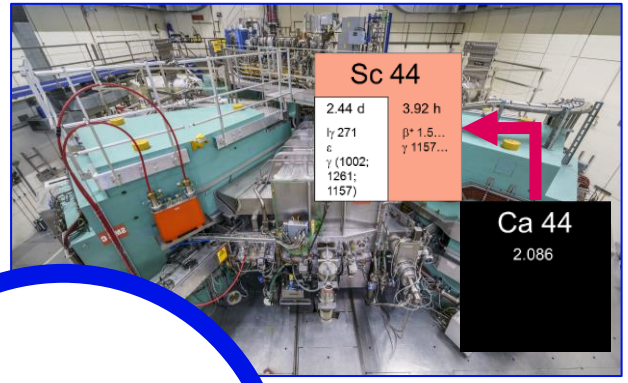
Courtesy: N. Cerboni

Radionuclide Development

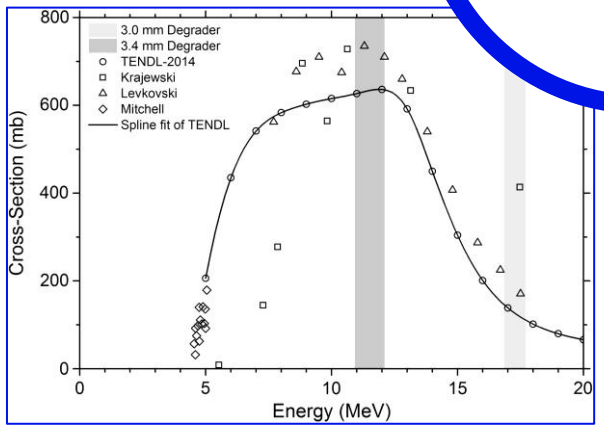
RADIONUCLIDE DEVELOPMENT ETH zürich PSI

Target preparation

Proton irradiation

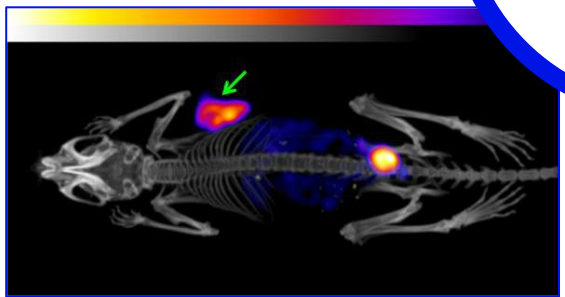


Nuclear data



Chemical separation

Preclinical study

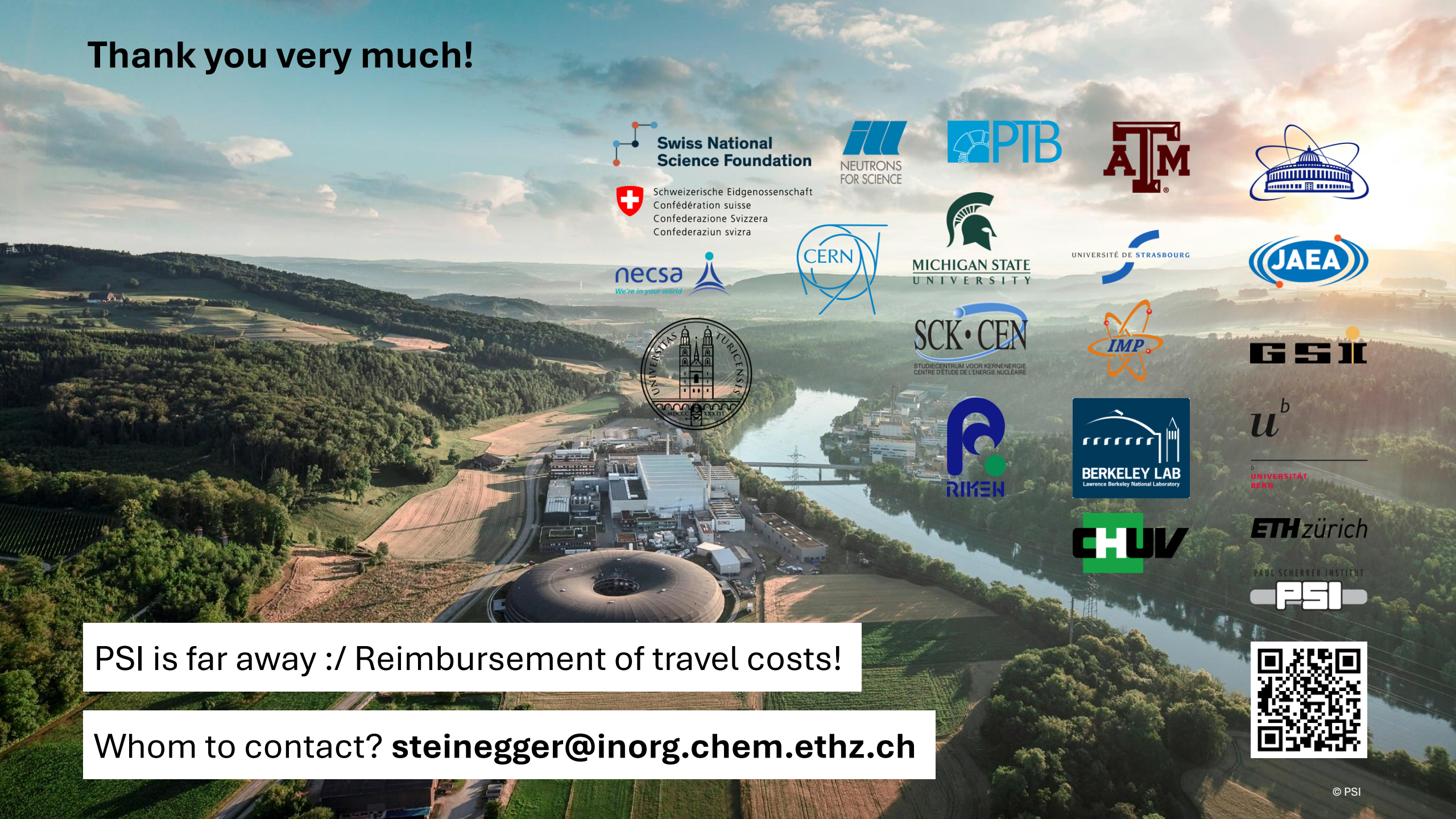


Grundler *et al.*, Chimia (2020); van der Meulen *et al.*, Proc. Cyclotrons2019 (2019); van der Meulen et al., Nucl. Med. Biol. (2015)

What can you learn?

- Production and handling of radionuclides
- Identification and quantification of radionuclides using nuclear spectroscopy
- Radiochemical separations (gas-/liquid-phase)
- SEM & EDX in radioactive area
- Standard analytical techniques (XPS, AFM, IR, Raman, and more)
- Vacuum technology
- Monte-Carlo simulations
- Thin film preparations of radionuclides for various purposes (e.g., half-life)
- Electrochemistry in the aqueous phase or in ionic liquids

Thank you very much!



PSI is far away :/ Reimbursement of travel costs!

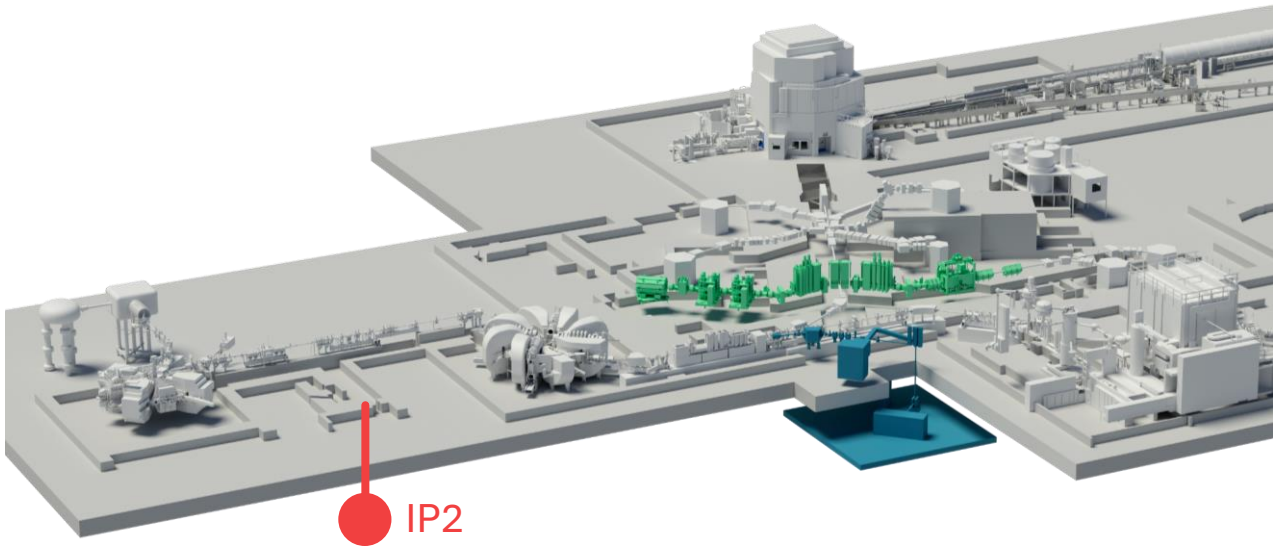
Whom to contact? **steinegger@inorg.chem.ethz.ch**

© PSI

The large-scale research facilities of PSI for the production of radionuclides

PAUL SCHERRER INSTITUT PSI

Nuclear reactions (p)

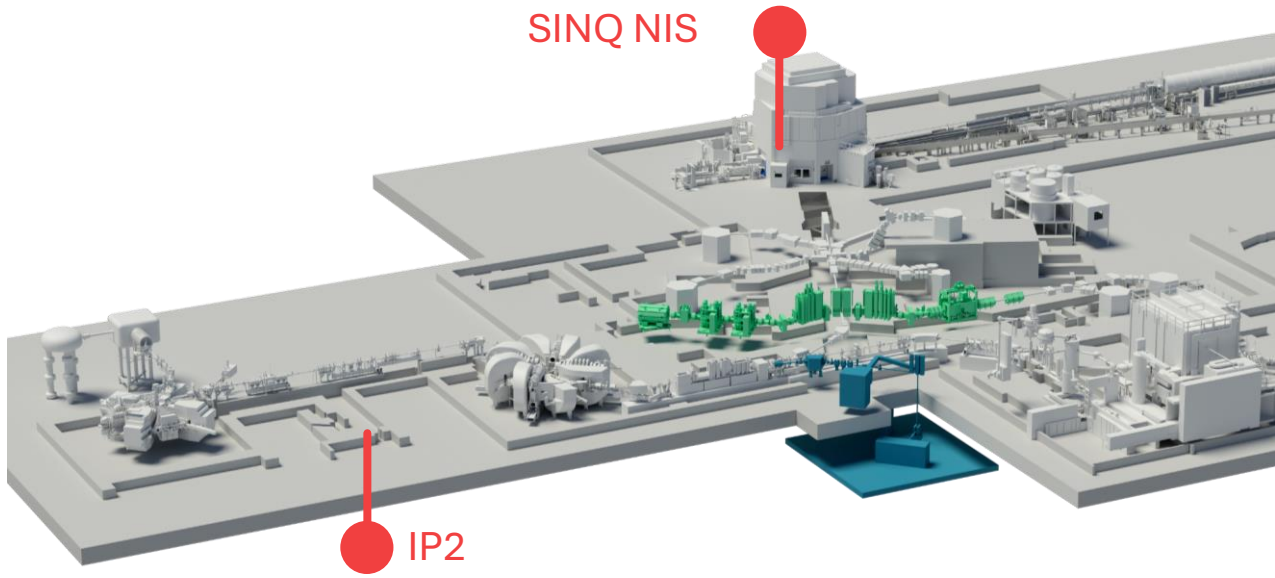


Bilder: PSI

ETH zürich PSI

PAUL SCHERRER INSTITUT PSI

Nuclear reactions (n)



Bilder: PSI

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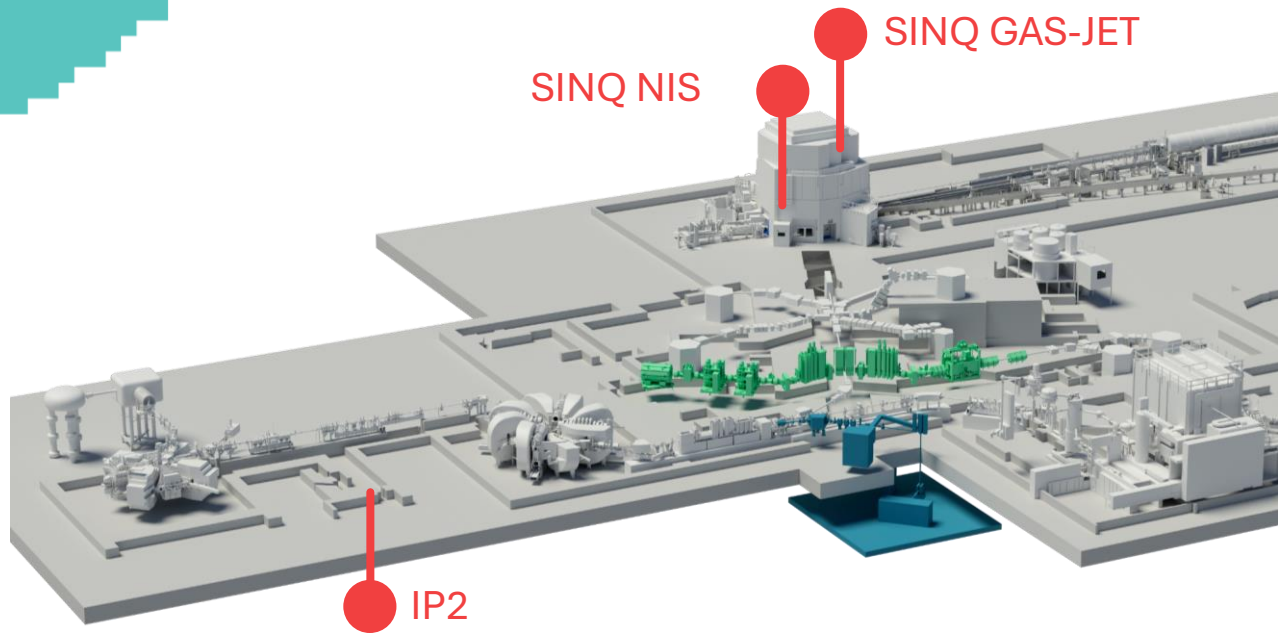
Nuclear reactions (f)



Bilder: PSI

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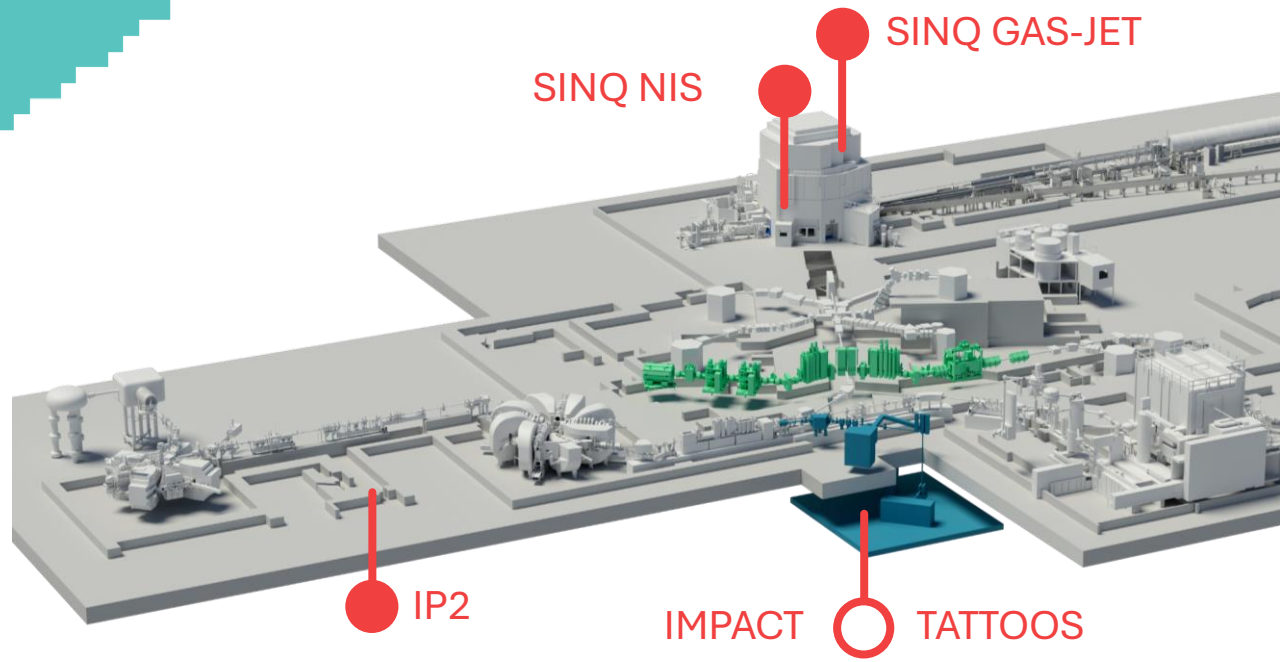
Nuclear reactions (sp)



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